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B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2011

Fourth Semester

Electrical and Electronics Engineering

EE 2251 — ELECTRICAL MACHINES — I

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions

PART A — ($10 \times 2 = 20$ marks)

1. What are the three types of basic rotating electric machines?

2. A conductor 80 cm long moves at right angle to its length at a constant speed of 30 m/s in a uniform magnetic field of flux density 1.2 T. Find the emf induced when the conductor motion is normal to the field flux.

3. Which equivalent circuit parameters can be determined from the open-circuit test on a transformer?

4. The emf per turn for a single-phase 2200/220 V, 50 Hz transformer is 11 V. Calculate the number of primary and secondary turns.

5. Based on the principle of conservation of energy, write an energy balance equation for a motor.

6. What are the three basic principles for the electromechanical energy conversion?

7. What is magnetic leakage flux?

8. Why is the efficiency of a three-phase induction motor less than that of a three-phase transformer?

9. Draw the circuit model of dc shunt motor.

10. What is the function of no-volt release in a three-point starter?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Discuss in detail the magnetic circuits and the electrical analog of magnetic circuits. (10)

(ii) What is eddy-current? Explain in detail the eddy-current loss. (6)

Or

(b) (i) Explain the power losses that occur in a magnetic material when it undergoes cyclic magnetization. (10)

(ii) The total core loss of a specimen of silicon steel is found to be 1500 W at 50 Hz. Keeping the flux density constant the loss becomes 3000 W when the frequency is raised to 75 Hz. Calculate separately the hysteresis and eddy current loss at each of those frequencies. (6)

12. (a) The following data were obtained on a 20 kVA, 50 Hz, 2000/200 V distribution transformer :

	Voltage (V)	Current (A)	Power (W)
OC test with HV open-circuited	200	4	120
SC test with LV short-circuited	60	10	300

Draw the approximate equivalent circuit of the transformer referred to the HV and LV sides respectively. (16)

Or

(b) (i) A 3-phase transformer bank consisting of three 1-phase transformers is used to step-down the voltage of a 3-phase, 6600 V transmission line. If the primary line current is 10 A, calculate the secondary line voltage, line current and output kVA for the following connections :

(1) Y/Δ and

(2) Δ/Y. The turn's ratio is 12. Neglect losses. (8)

(ii) A 20 kVA, 2500/500 V, single-phase transformer has the following parameters :

HV winding : $r_1 = 8\ \Omega$ and $x_1 = 17\ \Omega$

LV winding : $r_2 = 0.3\ \Omega$ and $x_2 = 0.7\ \Omega$

Find the voltage regulation and the secondary terminal voltage at full load for a pf of 0.8 lagging and 0.8 leading. The primary voltage is held constant at 2500 V. (8)

13. (a) (i) Describe the flow of energy in electromechanical devices. (6)

(ii) Discuss about the 'field energy' and 'coenergy' in magnetic system. (4)

(iii) The magnetic flux density on the surface of an iron face is 1.6 T which is a typical saturation level value for ferromagnetic material. Find the force density on the iron face. (6)

Or

(b) A doubly-excited magnetic field system has coil self- and mutual-inductances of

$L_{11} = L_{22} = 2H$ and $L_{12} = L_{21} = \cos\theta$

Where θ is the angle between the axes of the coils.

(i) The coils are connected in parallel to a voltage source $v = V_m \sin \omega t$. Derive an expression for the instantaneous torque as a function of the angular position θ. Find there from the time-average torque. Evaluate for $\theta = 30°$, $v = 100 \sin 314t$. (8)

(ii) If coil 2 is shorted while coil 1 carries a current of $i_1 = I_m \sin \omega t$, derive expressions for the instantaneous and time-average torques. Compute the value of the time-average torque when $\theta = 45°$ and $i_1 = \sqrt{2} \sin 314t$. (8)

14. (a) (i) 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. (8)

(ii) A 4-pole, lap-wound dc machine has 728 armature conductors. Its field winding is excited from a dc source to create an air-gap flux of 32 mWb/pole. The machine (generator) is run from a prime mover (diesel engine) at 1600 rpm. It supplies a current of 100 A to an electric load.

(1) Calculate the electromagnetic power developed. (4)

(2) What is the mechanical power that is fed from the prime-mover to the generator? (2)

(3) What is the torque provided by the prime mover? (2)

Or

(b) (i) A 3-phase, 50 kW, 4-pole, 50 Hz induction motor has a winding (ac) designed for delta connection. The winding has 24 conductors per slot arranged in 60 slots. The rms value of the line current is 48 A. Find the fundamental of the mmf wave of phase-A when the current is passing through its maximum value. What is the speed and peak value of the resultant mmf/pole? (12)

(ii) A 4-pole synchronous generator driven at 1500 rpm feeds a 6-pole induction motor which is loaded to run at a slip of 5%. What is the motor speed? (4)

15. (a) (i) A 220 V dc generator supplies 4 kW at a terminal voltage of 220 V. the armature resistance being 0.4 Ω. If the machine is now operated as a motor at the same terminal voltage with the same armature current, calculate the ratio of generator speed to motor speed. Assume that the flux/pole is made to increase by 10% as the operation is changed over from generator to motor. (6)

(ii) A 220 V, 7.5 kW series motor is mechanically coupled to a fan. When running at 400 rpm the motor draws 30 A from the mains (220 V). The torque required by the fan is proportional to the square of speed. $R_a = 0.6\ \Omega$, $R_{se} = 0.4\ \Omega$. Neglect armature reaction and rotational loss. Also assume the magnetization characteristic of the motor to be linear.

(1) Determine the power delivered to the fan and torque developed by the motor. (5)

(2) Calculate the external resistance to be added in series to the armature circuit to reduce the fan speed to 200 rpm. (5)

Or

(b) A 250-V dc shunt motor has $R_f = 150\ \Omega$ and $R_a = 0.6\ \Omega$. The motor operates on no-load with a full field flux at its base speed of 1000 rpm with $I_a = 5$ A. If the machine drives a load requiring a torque of 100 Nm, calculate armature current and speed of motor. If the motor is required to develop 10 kW at 1200 rpm what is the required value of the external series resistance in the field circuit? Assume linear magnetization. Neglect saturation and armature reaction. (16)
