Total number of printed pages – 8 **B. Tech**

BENG 1201

Fourth Semester Examination – 2008

ELECTRICAL MACHINES

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

   (a) A d.c. shunt machine develops an open circuit emf of 250 V at 1500 RPM. Find the developed torque for an armature current of 10 A.

   (b) Mention with reason the type of d.c. motor used for loads requiring high starting torque.

   (c) Why is it desirable for the starting lever of the starter of a d.c. shunt motor to fall back to 'off' position when the power fails ?

   (d) The 'voltage regulation' of a transformer will be zero for a leading power factor load. Justify this statement.

   (e) Draw the phasor diagram of the cylindrical rotor synchronous generator supplying a leading power factor load. Show the mmf (magneto-motive-force) space phasors in the same diagram.

   (f) Calculate the 'pitch factor' and 'distribution factor' of a 3-phase balanced winding having a coil span of 8 slots with 72 stator slots and 8 poles.

   (g) A three-phase cylindrical rotor synchronous motor, fed from an infinite bus, is operating at unity power factor while driving its rated full load. What will be the nature of its operating power factor if its excitation is increased to 120% of its normal value without changing its shaft load ?

(h) Calculate the 'slip frequency' and 'slip speed' of a 6-pole 3-phase induction motor drawing power from a 3-phase, 110 V, 60 Hz source and running at 1140 RPM.

(i) A three-phase, 60-hertz induction motor having six poles runs at a full load speed of 1140 RPM. What will be the speed of rotation of its rotor field with respect to the stator structure and also with respect the stator field ?

(j) Why the developed torque in case of a single-phase induction motor is zero at starting ? Explain by drawing its torque-speed characteristic.

2. (a) A 250 V d.c. shunt motor has an armature resistance of 0.5 ohm and field resistance of 250 ohms. The armature takes 25 A while driving a constant load torque at 750 RPM. What resistance must be inserted in the shunt field circuit to raise the speed from 750 RPM to 950 RPM assuming the magnetic curve to be a straight line ? 5

(b) Describe the working of a three-point starter for a d.c. shunt motor with the help of a neat diagram. How does a four-point starter differ from this ? What are the advantages of the four-point starter ? 5

3. (a) Describe, with relevant diagrams, the different methods of excitation of d.c. generators. Explain the meaning of the terms 'differentially compounded', 'cumulatively compounded'. Show the 'long shunt' and 'short shunt' connection diagrams. 5

(b) A d.c. series motor runs at 750 RPM drawing 50 A from 500 V supply. The armature resistance is 0.25 ohm and the series field resistance is 0.2 ohm. Determine the value of the external resistance to be added in series with the armature for the motor to run at 550 RPM. The load torque varies as the square of the speed. Assume linear magnetization. 5

4. (a) Derive the 'electro-motive-force (emf) equation' of a single-phase two-winding transformer from first principles. 3

(b) What is 'Polarity Test' ? Why and how this should be performed in a single-phase two winding transformer ? Explain clearly with the help of the connection diagram. 3

(c) A single-phase autotransformer is to deliver a power of 200 kW at unity power factor at 240 volts with an input voltage of 300 volts. Determine the kVA rating of each section of the autotransformer winding. 4

5. (a) The efficiency of a 22 kVA, 2200/220 V, single phase transformer at unity power factor is 98.5% at rated load. At half rated load with unity power factor, the efficiency is the same 98.5%. Determine the transformer core loss and copper

loss and the per unit value of its equivalent resistance. Also determine the maximum value of the efficiency and the load at which it occurs. 6

(b) Three single-phase transformers are connected in star-delta with the high voltage winding in star connection. Draw the connection diagram and phasor diagram for both the high voltage and low voltage windings. Label the phasors clearly. 4

6. (a) Derive the expressions for the 'pitch factor' and the 'distribution factor' of a three-phase balanced short-pitched distributed winding used in an alternator. 5

(b) A 300 MVA, 11 kV, 50 Hz, star connected three phase alternator has an effective armature resistance per phase = 0.02 ohm and synchronous reactance per phase = 2.25 ohms. Find the voltage regulation for a power factor of 0.707 lagging. What is the load angle of the alternator under this condition ? 5

7. (a) Draw neatly and explain the family of 'V-curves' showing the variation of stator input current with respect to the field exciting current of a three-phase synchronous motor operating at 25%, 50%, 75% and 100% of full load. Why more field ampere-turns is required to maintain the unity power factor at higher loads ? 5

(b) A 700 kW, 11 kV , 50 Hz, 3-phase, star-connected synchronous motor has a full load efficiency of 92%. The synchronous impedance of the motor is (0.15 + j15) ohms per phase. The excitation of the motor is adjusted to give an operating power factor of 0.85 leading. Under this operating power factor and full load conditions, compute 5

(i) the per-phase induced emf and

(ii) the load angle.

8. (a) Any variation in the rotor resistance of a three-phase induction motor does not affect the magnitude of its maximum

torque whereas it does affect the speed at which the maximum torque occurs. Justify the answer with proof. 4

(b) A 6.6 kV, 10-pole, 50 Hz, 3-phase, star-connected three-phase induction motor has a slip ring rotor of resistance 0.015 ohm per phase and standstill reactance of 0.35 ohm per phase. The motor has a speed of 560 RPM while delivering its rated full load torque. Compute the slip at maximum torque and the ratio of maximum torque to full load torque. Neglect the stator impedance drop. 4

(c) Explain why a capacitor is connected in one of the windings of single-phase induction motor ? 2

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