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B. Tech

BENG 1201

Third 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 for the questions.

1. Answer the following questions : 2×10

   (a) What is the function of an 'interpole' in a d.c. machine ? Where it is situated in a d.c. machine and why its winding is connected in series with the armature winding ?

P.T.O.

(b) Mention any two reasons for which a d.c. shunt generator may fail to build up voltage across its armature terminals.

(c) Why the series field conductors are thicker and less in number in comparison to the shunt field conductors of a d.c. machine ? Explain.

(d) Draw the equivalent circuit of a single-phase transformer supplying full load at 0.8 power factor lagging. Name the various parameters of the equivalent circuit.

(e) Draw the power angle characteristic of a cylindrical rotor three-phase synchronous motor neglecting its stator resistance. Find out the load angle for which the power developed becomes maximum.

(f) Calculate the 'distribution factor' and 'pitch factor' of the 3-phase balanced winding having 54 stator slots, 6 poles and coil span of 8 slots.

(g) Draw the curve showing variation in stator input current with variation in field current in case of a synchronous motor for 25% and 100% loads.

(h) Calculate the 'slip speed' and 'slip frequency' of a 6-pole 3-phase induction motor drawing power from a 3-phase, 440 V, 50 Hz source and running at 970 rpm.

(i) Explain, in brief, why the developed torque of a three-phase induction motor is zero at synchronous speed.

(j) Draw the circuit diagram showing the connection of the main running winding and auxiliary starting winding of a single-phase induction motor using a capacitor for its starting purpose.

2. (a) A 250 V d.c. shunt motor takes a full load line current of 50 A. The armature and field resistances are 0.4 ohm and 250 ohms

respectively. The total brush contact drop is 2 V. The core and friction losses are 500 watts. Assume the stray load losses to be equal to 90 watts. Calculate the output and efficiency of the motor. 5

(b) Draw neatly the diagram of a 4-point starter of a d.c. shunt motor and explain its principle of operation. Which demerit of the 3-point starter is eliminated here ? 5

3. (a) Explain the voltage build-up process in case of a d.c. shunt generator. What are the factors affecting this process ? How can a d.c. shunt generator regain its lost residual field flux ? 5

(b) A separately excited d.c. generator operating at a voltage of 'V' volts has an armature circuit resistance of 'R_a' ohm. It has a constant loss of 'P_c' watts. It delivers an armature current of 'I_a' amperes. Derive the expression for the armature

current 'I_a' for obtaining maximum generator efficiency. 5

4. (a) Derive an expression for the 'voltage regulation' of a single phase transformer in terms of its per unit resistance and per unit leakage reactance for a leading power factor load. For what value and nature of power factor, the voltage regulation will be zero ? 5

(b) The parameters of the equivalent circuit of a single phase, 50 Hz, 200-kVA, 2300 V/230 V transformer are as follows :

HV winding resistance = 0.22 ohm. LV winding resistance referred to HV winding = 0.18 ohm. HV winding leakage reactance = 0.5 ohm. LV winding leakage reactance referred to HV winding = 0.5 ohm. Resistance representing core loss in the transformer referred to HV side = 15 kilo-ohm. The magnetizing reactance of the transformer referred to HV side = 2 kilo-ohm. Determine the voltage regulation of the transformer operating at rated load with 0.707 lagging power factor. 5

5. (a) Explain how three single-phase two winding transformers can be connected in 'star-delta' ? The source side is star connected. Show the connection diagram and draw the phasor diagram of induced voltages (both star and delta sides) for this connection. 4

(b) It is desired to have a 5 mWb maximum core flux in a transformer at 230 V and 50 Hz. Determine the required number of turns in the primary. 2

(c) A single-phase 50 Hz transformer takes 100 watts of power at 1 A and 230 V while operating at no-load. If the primary winding resistance is 0.55 ohm, find the core loss and the no-load power factor. 4

6. (a) Draw neatly the phasor diagram of a cylindrical rotor three-phase synchronous generator supplying rated power to a load at unity power factor. Show the mmf space phasor diagram and emf time phasor diagram together in the same figure and explain the various phasors briefly. 5

(b) A 250 MVA, 11 kV, 50 Hz, star connected three phase alternator has a synchronous impedance of (0.13 + j1.87) ohms per phase. Find the no-load induced emf per phase while the generator is supplying rated full load at a power factor of 0.707 lagging. What is the load angle of the alternator under this condition ? 5

7. (a) Explain why a three-phase synchronous motor has no self-starting torque. Describe any two methods of starting it. 5

(b) A 3 phase, 11 kV star connected synchronous motor draws a current of 70 A from the mains. The effective per-phase synchronous impedance of the motor is (0.5 + j5) ohms. Find the per-phase induced emf and load angle 'delta' for an operating power factor of 0.707 leading. 5

8. (a) The power input to the rotor of a 3-phase, 50 Hz, 6-pole induction motor is 100 watts. The rotor induced emf makes 120 revolutions per minute. Find slip, rotor speed, mechanical power developed, rotor copper loss and the torque developed. 5

(b) Develop, step by step, the per phase equivalent circuit of a three-phase induction motor from first principles like a single-phase or three-phase transformer. 5