C 18235 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION, JUNE 2011

EE 04 605—ELECTRICAL MACHINE DESIGN

(2004 admissions)

Time : Three Hours Maximum : 100 Marks

Answer **all** *questions.*

I. (a) What is meant by specific electric loading of a DC machine ? Enumerate the factors affecting the specific electric loading.

(b) Explain the phenomenon of commutation in DC machines.

(c) Derive the output equation of a 3-phase transformer.

(d) Briefly explain the cooling methods employed in transformers.

(e) What is Short Circuit Ratio (SCR) in the case of synchronous machines ? Explain its effects on the machine performance.

(f) Explain the procedure for the design of field windings for a synchronous machine.

(g) What are the different methods used for improving the starting torque of a squirrel cage induction motor ?

(h) Enumerate the various steps in the design of rotor in slip ring induction motor.

($8 \times 5 = 40$ marks)

II. (a) (i) Explain armature reaction in DC machines. How it can be reduced ? (5 marks)

(ii) A 4 pole generator supplies a current of 140 A. It has 480 armature conductors. The brushes are given an actual load of 10°. Calculate the cross magnetising and demagnetising mmf per pole when the armature in (1) wave connected ; (2) lap connected.

The field winding is shunt connected and takes a current of 10 A. Find the number of extra shunt field turns to neutralise the demagnetisation.

(10 marks)

Or

(b) (i) Explain commutation in DC machines. What are the different forms of commutation ?

(7 marks)

(ii) A 1500 kW, 500 V, 300 r.p.m. 14 pole lap connected d.c. generator has 287 slots and 574 single turn coils. The diameter of armature is 2 m. and core length 0.28 m. Find

(1) Number of turns on each interpole ;

(2) Commutating flux in the air-gap ;

(3) Time of commutation ; and

(4) e.m.f. generated in the short circuited coil.

Turn over

Given :

Air-gap length under interpole =10 mm. ; flux density under interpole = 0.3 Wb/m.^{2} ; mmf required for iron parts = 20 % of gap mmf ; width of interpole = 2 slot pitches ; width of flux path in commutating zone = 1.2 × width of interpole ; length of interpole = 0.28 m. ; gap contraction factor = 1.1.

(8 marks)

III. (a) Calculate the main dimensions and winding details of a 100 kVA, 2000/400 V, 50 Hz, single-phase shell type, at immersed, self-cooled transformer. Assume voltage per turn = 10 V, flux density in the core = 1.1 Wb/m.^{2}, current density = 1.5 A/mm.^{2} window space factor 0.33.

The ratio of window height to window width and ratio of core depth to width of central limb = 2.5. The stacking factor is 0.9.

(15 marks)

Or

(b) (i) Discuss the design of tank with tubes for the cooling of transformers. **(5 marks)**

(ii) A 1000 kVA, 6600/440 V, 50 Hz, 3-phase delta/star, core type oil immersed, natural cooled (ON) transformer. The design data of the transformer is :

Distance between centre of adjacent limbs = 0.47 m. ;

Outer diameter of h.v. winding = 0.44 m. ;

Height of frame = 1.24 m. ;

Core loss = 3.7 kW and

I^2R loss = 10.5 kW.

Design a suitable tank for the transformer. The average temperature rise of oil should not exceed 35°C. The specific heat dissipation from the tank walls is 6 W/m.^{2}-°C., and 6.5 W/m.^{2}-°C. due to radiation and convection respectively. Assume that the convection is improved by 35 % due to provision of tubes.

(10 marks)

IV. (a) (i) Enumerate the various factors to be considered in the design of stator for synchronous machines.

(5 marks)

(ii) Estimate the diameter, core lenth, size and number of conductors, number of slots for stator of a 15 MVA, 11 kV, 50 Hz, 2 pole star connected turbo-alternator with 60° phase spread. Assume B_{av} = 0.55 Wb/m.^{2} ; ampere conductors = 36000 A/m. ; current density = 5 A/mm.^{2} ; peripheral speed = 160 m./s.

The windings should be arranged to eliminate 5th harmonic.

(10 marks)

Or

(b) (i) Give a comparison between single layer and double layer windings in the armature design of synchronous machines.

(5 marks)

(ii) Determine a suitable number of slots and conductors per slot for the stator winding of a 3-phase, 3300 V, 50 Hz, 300 r.p.m., alternator. The diameter is 2.3 m. and the axial length of core is 0.35 m. The maximum flux density in the air-gap should be approximately 0.9 Wb/m.^{2} Assume sinusoidal flux distribution. Use single layer winding and star connection for stator.

(10 marks)

V. (a) (i) Explain the harmonic torques in induction motors. Explain the causes and effects of these harmonic torques. Also give the methods employed for the reduction of those effects.

(12 marks)

(ii) A 3-phase, 4 pole induction motor has 24 slots. Calculate the order of slot harmonics produced. It is desired to completely eliminate the higher order slot harmonic, find the angle through which the bars must be skewed. Find the effect of skewing on the lower order harmonics.

(3 marks)

Or

(b) Calculate the equivalent resistance of rotor per phase referred to stator, from the following data of a 400 V, 3-phase, 4 pole, 50 Hz cage motor.

Stator slot = 48 with 30 conductors per slot ; Rotor slots = 53 with one bar on each slot. The length of each rotor bar is 0.12 m. and area 60 mm.^{2} The end rings have a mean diameter of 0.18 m. and an area of cross-section 150 mm.^{2}

Full pitch winding with 60° phase spread is used for the stator. The material used for bars and end rings has a resistivity of 0.021 Ωm.

(15 marks)

[4 × 15 = 60 marks]