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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Electrical and Electronics Engineering

Semester End Examination; May/June - 2019

Electrical Machine Design

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

ii) Use of Design data hand book is permitted.

UNIT - I

1 a. List any six important insulating materials used in modern electrical machines and briefly explain their desirable properties. 6

b. Explain how the following factors are affected by the choice of specific electric loading in DC machines : 6

i) Armature reaction ii) Commutation iii) Temperature rise

c. Determine the suitable main dimensions and number of poles for a 200 kW, 250 V, 1000 rpm DC generator. The following design parameters may be assumed: maximum value of the flux density = 0.87 Wb/m^2, specific electric loading = 310 ac/cm, efficiency = 0.91, ratio of pole arc to pole pitch = 0.67, ratio of the core length of the pitch = 0.75. 8

2 a. Show that the output of a DC machine with single turn coil is given by the expression;

$$P = \frac{3Aq\overline{E}V_P}{PN}$$

Where A = number of parallel paths, q = specific electric loading

$\overline{E}$ = Average voltage between commutator segments

V_P = Peripheral speed in m/s, P = Number of poles, N = speed in rpm 10

b. Estimate the diameter and length of armature core for a 55 kW, 110 V, 1000 rpm, 4 pole shunt generator assuming specific electric and magnetic loadings as 260 ac/cm and 0.5 Tesla respectively. The pole arc should be about 70% of pole pitch and length of core about 110% of pole arc. Allow 10 amperes for field current and voltage drop of 4 volts for the armature circuit. Specify the type of winding and also estimate suitable values for number of armature conductors and number of slots. 10

UNIT - II

3 a. An armature winding is to be designed for a 500 kW, 460 V, 375 rpm, 8 pole DC compound generator having following details :

External diameter of armature = 105 cm, Gross armature length = 37 cm, Flux per pole = 0.0885Wb, Internal voltage drop = 3% of rated voltage, shunt field current = 1 A 10

Estimate the following details of the armature winding :

i) Number of armature conductors ii) Number of slots

iii) Number of conds/slot iv) Dimensions of the slots

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b. A shunt generator with a speed of 450 rpm and lap connected winding has the following with respect to its magnetic circuit.

Parts	Yoke (Cart steel)	Pole (Cart steel)	Air gear (effective)	Teeth (effective)	Armature core (Stalloy)
Area (cm^2)	344	506	658	360	300
Length (cm)	30	25.5	0.8	4.1	18

10

Leakage coefficient = 1.17, Air gap flux /pole = 70 mWb. Find the ampere-turns per pole for this machine.

4 a. A 175 kW, 6 pole, 230 V, 350 rpm DC generator gave the following data during preliminary design calculations :

Armature diameter = 60 cm, Number of conductors = 680, Number of coils = 340, Calculate; 10

i) Diameter of the commutator ii) Number of brushes/spindle iii) Length of the commutator

b. Design the shunt field winding for a 300 kW, 440 V, 600 rpm, 6 pole, DC generator with following data :

Ampere turn for shunt field winding = 7000 Axial length of the pole = 26 cm

Width of the pole = 19 cm Height of the pole = 28 cm 10

Heat dissipation from surface of field coil is 0.0744 W/cm^2. Calculate;

i) Cross section of field conductor ii) Exciting current

iii) Number of turns iv) Number of layers

UNIT - III

5 a. With usual notations derive the output equation of a transformer and show that it is proportional to 4^{th} power of its linear dimensions. 10

b. Design a single phase transformer to be connected to 230 V 50 Hz supply. The transformer has to deliver 3 A at 50 V. Also determine the overall dimensions of the core. 10

6 a. A 250 kVA, 6600/440 V, 50 Hz, 3ϕ Star-delta, core type oil immersed natural cooled transformer is operating at an efficiency of 98% at a power factor of 0.93. The transformer has the following design parameters:

Length of core plus twice the height of Yoke = 85 cm, Centre to centre distance of core = 32 cm, outside dia of HV winding =31cm. Estimate; i) Dimension of the tank 10

ii) Temperature rise of transformer iii) Number of tubes if temperature rise is not to exceed 35°C.

b. Estimate the active and reactive components of no load current of a single phase 50 Hz, 6600 V/400 volts. Core type transformer with the following particulars; Height of the window = 60 cm, mean length of the yoke = 65 cm, gross sectional area of the core =140 cm^2, maximum flux density =1.2 Tesla, specific core loss at 1.2 Tesla = 2.3 W/kg. Ampere turns /cm for the transformer steel at 1.2 Tesla = 6.5 effect of joints is equivalent to an air gap of 1 mm in magnetic circuit iron space factor = 0.9, Yoke area is equal to core area. 10

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UNIT - IV

7 a. For a 3ϕ induction motor with usual notations derive an expression for output equation when the output is in HP and the induced emf is 5% less and the induced emf is 5% less than the terminal voltage. 8

b. A 20 HP, 400 V, 4 pole, 50 Hz, 3ϕ induction motor is build with stator bore of 25 cm and core length of 16 cm, specific electric loading is 230 ac/cm. Using the data of this machine estimate the core dimensions, number of slots, number of stator conductors and stator copper loss for a 15 HP, 460 V, 6 pole, 50 Hz, induction motor. Assume the full load efficiency as 0.84 and power factor as 0.83 for each machine. Design factional slot winding for second machine. 12

8 a. The stator of a 360 HP, 3000 V, 10 pole, 3ϕ, 50 Hz, induction motor has the following design details :

Stator bore diameter = 78 cm, Core length = 35cm, Number of stator slots = 120

Estimate number of conductors for slot and dimensions of the slot. 10

b. A squirrel cage rotor is to be designed for a 10 HP, 3ϕ, 50 Hz, 440 V with a synchronous speed of 1000 rpm. The full load efficiency = 0.85 full load, power factor = 0.86, Number of stator conductors = 1080, Number of stator slots = 54. Design the rotor for this motor. 10

UNIT - V

9 a. What is short circuit ratio? Show that SCR is inversely proportional to synchronous reactance. 8

b. Find the main dimensions of a 2500 kVA, 187.5 rpm, 50 Hz, 3ϕ, 3 kV, salient pole synchronous generator. Bar = 0.6 T, specific electric loading is 340 ac/cm. Core length to pole pitch ratio is 0.65. Use circular poles. 6

c. A 500 kVA, 3.3 kV, 50 Hz, 600 rpm, 3ϕ salient pole alternator has 180 turns phase. Estimate the length of the air gap if the average flux density is 0.54, Tesla ratio of pole arc to pole pitch is 0.66 SCR is 1.2, gap contraction factor is 1.15, and winding factor is 0.955. The mmf required for air gap is 80% of no load field mmf. 6

10 a. With usual notations derive an expression for height of the field coil of a salient pole alternator. 6

b. List and briefly explain the factors to be considered for elimination of harmonics in alternators. 4

c. A 588 MVA, 22 kV, 50 Hz, 2 pole, 3ϕ star connected water cooled turbo alternator has a stator bore of 1.3 m and a stator core length of 6.0 m. If the stator winding has 2 conductors per slot and there are 2 circuits per phase. Calculate number of stator slots and average flux density loading is 200 AC/cm and the winding factor is 0.92. 10

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