U.S.N

# 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; June - 2017**

**Electrical Machine Design**

Time: 3 hrs Max. Marks: 100

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
*ii) Missing data may suitably assume.*
*iii) Design data handbook may be permitted.*

**UNIT - I**

1. a What are the limitations involved in design of electrical machine? 6

b. Define 'Specific magnetic loading' and specific electric loading. What are the advantages and disadvantages of using higher specific loadings? 8

c. What are the electrical properties of insulating materials? Classify the insulating materials used in electrical machines according to their thermal stability in service. 6

2 a. Derive the output equation of a D.C. machine. 6

b. What are the advantages and disadvantages of large number of poles in D.C. machine? 4

c. Determine suitable valves for;

i) External diameter of armature ii) Core length

iii) Number of poles, for a 1000 kW, 500 volts, 350 rpm, DC generator, justify the value of diameter and length of armature from the limiting valve of peripheral speed and voltage between adjacent commutator segment respectively. 10

Assume: Specific magnetic loading = 0.962, Specific electric loading = 40,000

**UNIT - II**

3 a. Explain the factors which are considered when selecting the number of armature slots in D.C. machine. 8

b. Design the lap would armature winding for a 500 kW, 440 V, 375 rpm, 8 poles compound generator with external diameter of 1.1 m, gross armature length of 0.30 m and flux per pole of 0.0876 wb, Find the following details of winding: 12

i) Number of armature conductors ii) Number of slots

iii) Size of armature conductors iv) Dimensions of slots.

4 a. During the design of armature of a 250 kW, 400 V, 6 pole, 600 rpm, DC compound generator, following information has been obtained,

i) External diameter of armature 0.72 m

ii) Cross core length 0.25 m 10

iii) Flux per pole, 0.0585 wb, based on the above design information.

Contd …2

Find out the following details regarding the design of field system :

i) Axial length of pole ii) width of pole

iii) Height of pole iv) Pole arc

Assume pf = 725 W/$m^2$, sf = 0.6 and df = 0.045 m.

b. Following particular referred to shunt field coil for a 440 V, 6 pole DC generator, mmf/pole = 7000 AT. Depth of winding = 50 mm, length of inner turns = 1.1 m, length of outer turns = 1.4 m, loss radiated from outer surface excluding ends is 1400 W/$m^2$, space factor = 0.62, resistivity = 0.02 Ω$mm^2$/m. Calculate;

i) Diameter of wire ii) Length of coil iii) Number of turns

iv) Exciting current v) Height of field winding vi) Permissible loss

vii) Resistance of field winding

Assumes a voltage drop of 20% terminal voltage across the field regulator. 10

**UNIT - III**

5 a. Design the magnetic frame of 3-phase, 1250 kVA, 33/6.6 kV, 50 Hz, core type power transformer, based on the following information of design parameters.

| | |
|---|---|
| Maximum flux density in the core | $B_m$ = 1.5 Tesla |
| Average current density | $\delta$ = 2.5 A/$mm^2$ |
| Window space factors | $K_w$ = 0.21 |
| Net area of 3 stepped core | $A_i = 0.6\ d^2$ |
| Window proportions | = 3 : 1 |

Full load magnetic loading to mmf ratio = $1.687\text{x}10^{-6}$ 10

b. Explain the procedure to determine the no-load current of transformer with relevant expressions. 10

6. a Explain the design of tank with tubes for the transformer, starting from the determination of temperature rise of transformer. 10

b. Determine the dimension of core and yoke for a 100 kVA, 50 Hz-1ϕ core type transformer. A square core is used with distance between adjacent limbs equals to 1.6 times the width of the laminations. Assume voltage per turns of 14 V, maximum flux density 1.1 wb/$m^2$, window space factor = 0.32, current density = 3 A/$mm^2$. Take stacking factor = 0.9, flux density in the yoke to be 80% of flux density in the core. 10

**UNIT - IV**

7 a. Describe the factors that affect the estimation of length of air gap in the design of Induction motor. 10

Contd …3

b. Determine the main dimensions, turns/phase, number of slots, conductor's cross section and slot area of a 250 HP, 3ϕ, 50 Hz, 400 V, 1410 rpm, slipring Induction motor. Assume $B_{av}$ = 0.5 T, Q = 30,000 Ac/m, η = 0.9 and pf = 0.9 winding factor is 0.955, current density is 3.5 A/mm$^2$. The slot space factor is 0.4 and ratio of core length to pole pitch is 1.2. 10

8 a. What is meant by the terms 'Crawling' and 'Cogging' in case of 3 phases Induction motors? What steps would you take in the design procedure, so as to minimize these tendencies? 10

b. During the preliminary design of 270 kW, 3600 V, 3 phases, 8 poles, 50 Hz slipring Induction motor, star connected following information have been obtained.

Gross length of stator = 0.38 m

Internal diameter of stator = 0.67 m

Outer diameter of stator = 0.86 m

Number of stator slots = 96 10

Number of conductor per slot = 12

Based on the above information, determine the following design data's for this motor:

i) Flux per pole ii) Gap density iii) Conductor size

iv) Size of slot v) Copper losses.

**UNIT - V**

9 a. Define "Short Circuit Ratio" (SCR) for a synchronous generator. Explain affects of SCR on synchronous machine performance. 10

b. A 500 kVA, 3.3 kV, 50 Hz, 600rpm, 3ϕ alternator has 180 turns per phase. Estimate the length of air gap if the average flux density is 0.54 wb/m$^2$, the ratio of pole arc to pole pitch 0.65; the SCR 1.2, the gap contraction factor is 1.15 and the winding factor 0.955, The mmf required for gap is 80% of no load field mmf and the winding factor is 0.955. 10

10 a. Derive the output equation in terms of specific loadings for a synchronous machine. 10

b The following is the design data available for a 1250 kVA, 3 phase, 50 Hz, 3300 V, Star connected, 300 rpm alternator of salient pole type; stator core diameter D = 1.9 m; stator core length L = 0.335 m, pole arc/pole pitch is 0.66; turns per phase is 150; single layer concentric winding with 5 conductor per slot, short circuit ratio is 1.2. Assume that the distribution of gap flux is rectangular under the pole arc with zero valves in the inter polar region calculate: 10

i) Specific magnetic loading ii) Armature mmf per pole

iii) Gap density over pole arc iv) Air gap length

MMF required for air gap is 0.88 of no load field mmf and the gap contraction factor is 1.15.

* * * *