Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (EE-NEW)/SEM-6/EE-601/2010

2010

ELECTRICAL MACHINE DESIGN

Time Allotted : 3 Hours Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) The least desired property of a magnetic material for making electrical machines is

a) high electrical resistivity
b) high magnetic permeability
c) low loss coefficient
d) large hysteresis loop.

ii) Outside surface of electrical machines is painted with dull dark paints to

a) enhance cooling by radiation
b) enhance coolling by conduction
c) prevent corrosion
d) reduce heat loss.

iii) When a 3-phase induction motor as designed with higher value of B_{av} it will give

a) high full load p.f.

b) higher starting torque

c) higher full load efficiency

d) higher overload capacity.

iv) The purpose of providing an iron core in a transformer is to

a) provide support to windings

b) reduce hysteresis loss

c) reduce eddy current loss

d) decrease the reluctance to the magnetic path.

v) The maximum flux density of a rotating electrical machine occurs at

a) the air gap

b) the minimum tooth section of the rotor

c) the rotor core

d) the stator core.

vi) A 12 pole machine will pass through electrical degrees in one revolution of value

a) 60° b) 360°

c) 1080° d) 2160°.

vii) Harmonics torques can be reduced by

a) chording

b) integral slot winding

c) skewing

d) all of these.

viii) In squirrel cage induction motor, the rotor slots are made skewed to

a) reduce windage loss

b) reduce eddy current loss

c) reduce accumulation of dirt and dust

d) reduce magnetic locking.

ix) The minimum permissible temperature for Class-*B* insulation is

a) 90°C b) 105°C

c) 150°C d) 120°C.

x) The type(s) of slot normally used in induction motors is/are

a) semi-enclosed b) open

c) closed d) both (a) and (b).

xi) As volts per turn of a transformer increases, the per unit reactance will

a) not change b) decrease

c) inverse d) vary randomly.

xii) A distribution transformer has which one of the following as compared with power transformer ?

a) Low % impedance and low copper to iron loss ratio

b) High % impedance and low copper to iron loss ratio

c) Low % impedance and high copper to iron loss ratio

d) High % impedance and high copper to iron loss ratio.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. What is pulsation loss in electric machines ? What is slot leakage permeance ?

3. A heating furnace operates at 230 V and is made of nichrome wire. If the electric power input is 2·5 kW for raising the temperature to 1200°C, what should be the length and diameter of wire ? ρ = 0·424 Ω m at 1200°C, emissivity = 0·9 and radiating efficiency = 1. The ambient temperature is 20°C.

4. a) Which types of materials are used in the core of electromagnets ?

b) What is space factor ? What is its implication in electromagnet design. 2 + 3

5. Develop the design procedure of a choke.

6. a) Why are the few end turns of high voltage coils of transformer given reinforced insulation ?

   b) The voltage per turn of a transformer winding is given by $K\sqrt{(\text{ rated kVA })}$, where K may be regarded as a constant coefficient for a particular range of transformers of similar design. Discuss the factors affecting the value of K. 2 + 3

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Why is it necessary to use stranded conductors in large transformers ?

   b) Discuss the relative merits and demerits of core and shell type transformers.

   c) Calculate the overall dimensions of the magnetic frame (limb, yoke) for a 200 kVA, 6600/440 V, 50 Hz, 3 phase core type transformer. The following design data are available :

   e.m.f. per turn = 10 V,

   maximum flux density = 1·3 Wb/m^2 ,

   current density = 2·5 A/mm^2 ,

   window space factor = 0·3, stacking factor = 0·9, use a square core. 2 + 4 + 9

8. a) Discuss the phenomena of cogging and crawling and indicate with reasons how they are taken care of in the design of induction motors.

   b) Estimate the stator core dimension, number of stator slots and number of stator conductors per slot for a 100 kW, 3·3 kV, 50 Hz, 12 pole star connnected slip-ring induction motor. Assume :

   average gap density = 0·4 Wb/m^2 , specific electric loading = 25,000 A/m, efficiency = 0·9, power factor = 0·9 and winding factor = 0·96. Choose the main dimension to give best power factor. The slot loading should not exceed 500 ampere conductor. 6 + 9

9. a) What are the sources of stray iron losses in an electrical machine ?

   b) Calculate the specific iron loss in a specimen of alloy steel for a maximum flux density of 3·5 W/m^2 and a frequency of 50 Hz, using 0·5 mm thick laminations. The resistivity of alloy steel is $0·4 \times 10^{-6}$ Ω/m. Its density is 7800 kg/m^2 . Hysteresis loss in each cycle is 500 J/m^3 . 8 + 7

10. a) What are the mechanical forces that are developed in transformer windings ?

    b) Write a short note on 'change of parameters of a transformer with change of frequency'.

    c) The ratio of flux to full load mmf in a 500 kVA, 50 Hz, single phase core type power transformer is $2·4 \times 10^{-6}$. Calculate the net iron area and the window area of the transformer. B_m = 1·3 Wb/m^2 , current density = 2·7 A/mm^2 and window space factor 0·26. Also calculate full load mmf. 5 + 5 + 5

11. a) Which factor should be considered when estimating the length of the air gap of induction motor ? Why should the air gaps be as small as possible ?

b) What are the effects of space harmonics ?

c) A 3-phase, 4-pole, 50 Hz induction motor has 24 stators and 28 rotor slots. Prove that it has a tendency to run as a synchronous motor at 214·3 r.p.m. 5 + 5 + 5