Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/(EE-OLD)/SEM-6/EE-601/2013

2013

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 : $10 \times 1 = 10$

   i) The transformer laminations are insulated from each other by

      a) mica strip

      b) thin coat of varnish

      c) paper

      d) all of these.

   ii) For large capacity transformer, the core cross-section is

      a) multi-stepped b) square

      c) rectangular d) circular.

iii) The leakage reactance of a transformer is

a) directly proportional to number of turns

b) proportional to square of number of turns

c) inversely proportional to number of turns

d) inversely proportional to square of number of turns.

iv) 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.

v) The maximum permissible temperature for class *A* insulation is

a) 90˚C b) 105˚C

c) 155˚C d) 180˚C.

vi) Outside surfaces of electrical machines are painted with dull dark paints to

a) enhance cooling by radiation

b) enhance cooling by conduction

c) prevent corrosion

d) reduce heat loss.

vii) Radial ventilating ducts placed on the armature surface

a) enhance cooling

b) increase effective air gap length

c) increase magnetizing current

d) all of these.

viii) Coils used in loading rheostat are made of

a) Iron-constantan b) Nichrome

c) Copper d) Both (a) & (b).

ix) The air gap of a polyphase induction motor is kept small to

a) reduce the possibility of crawling

b) reduce noise

c) reduce the magnetizing current

d) obtain high starting torque.

x) The crawling in an induction motor is caused by

a) high loads

b) low voltage supply

c) improper design of machine

d) harmonics developed in motor.

xi) To increase the power factor of induction motor specific magnetic loading is

a) increased b) decreased

c) remained same d) none of these.

xii) In mush winding two conductors in adjacent slots are of

a) same length

b) different lengths

c) both (a) and (b) can be used

d) none of these.

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

a) high full load *pf*

b) a higher starting torque

c) higher full load efficiency

d) higher overload capacity.

xiv) A large value of ampere-conductors per metre means

a) greater amount of copper is used in the machine

b) space required for insulation is less

c) less number of turns per phase

d) less temperature rise.

GROUP – B
(Short Answer Type Questions)

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

2. a) Explain why "mitered" core is preferred to the conventional core in power transformer.

b) Why does the yoke of a transformer have the larger section than the limb ? 3 + 2

3. a) Air pocket in the insulation of a machine would have disastrous effects on heat dissipation. Explain.

   b) The initial temperature of a machine is 40°C. Calculate the temperature of the machine after 1 hour if its final steady state temperature rise is 80°C and the heating time constant is 2 hours. The ambient temperature is 30°C. 2 + 3

4. a) Why is stepped core used in transformers ?

   b) Why is LV winding placed nearer to the core and HV winding outside in a transformer ? 2 + 3

5. a) Discuss the factors affecting the choice of maximum flux density while designing a transformer.

   b) Why is it allowable to have higher current density in HV winding than LV winding ? 3 + 2

6. a) Explain that for a given frequency and maximum flux density, the hysteresis loss in 'soft' magnetic material is less than in 'hard' magnetic material.

   b) A specimen of a cold rolled grain oriented 0.3 mm thick stampings has a resistivity of $0{\cdot}5 \times 10^{-6}$ Ω – m. The hysteresis loop is rectangular with a coercive force of 12A/m and a peak flux density of 1 tesla. Calculate the loss in the material at 100 Hz when its density is 7650 kg/m^3. 2 + 3

7. A heating furnace operates at 230V 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 ? Resistivity of nichrome is 0.424 ohm-m at 1200°C, emissivity = 0.9 and radiating efficiency = 1. The ambient temperature is 20°C.

GROUP – C
(Long Answer Type Questions)

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

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

   b) Why is it necessary to use stranded conductors in large 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 : emf per turn = 10V, maximum flux density = 1.3 Wb/m^2, current density = 2.5A/mm^2, window space factor = 0.3, stacking factor = 0.9. Use a square core. 3 + 3 + 9

9. a) 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. Give an analytical support in favour of the discussion.

   b) Explain why the LV and HV current densities are kept nearly the same in transformers.

   c) A 25 kVA, 6600/440V, 50 Hz, 3-phase, delta/star core-type transformer has the following data :

emf per turn	=	2.12 V
Window space factor	=	0.3
Maximum flux density	=	1.1 tesla
Current density	=	2.3 A/mm^2
Window height/window width	=	3

   For a cruciform core, find (i) diameter of the circumscribing circle, (ii) width and height of window, (iii) conductor cross-section for both windings, and (iv) turns per phase in both windings. 5 + 2 + 8

10. a) In spite of increase in the heat dissipating surface of the transformer tank, why are special methods of cooling required as the rating of transformer increases ? Describe in brief the various cooling methods.

b) A 300 kVA, 11000/440V, 50Hz, 3-phase, delta/star, core type, oil immersed, self cooled transformer has the following parameters :

Centre to centre distance between cores	= 36 cm
Window height	= 44 cm
Height of yoke	= 17 cm
Total weight of iron	= 700 kg
Specific iron loss	= 2.1 watt/kg
Outer diameter of HV winding	= 35 cm
LV winding resistance per phase	= 0.0047 ohm
HV winding resistance per phase	= 9.47 ohm
Tank clearances (length, width and height)	= 8 cm, 10 cm and 45 cm respectively.

Based on the above, calculate the tank dimensions, temperature rise of the transformer with plain tank and number of cooling tubes, if the temperature rise is not to exceed 40°C. 5 + 10

11. a) How are the harmonic fields generated in an induction motor ? How do they affect the operation of the machine ?

b) What are the guiding factors in selecting the number of stator slots of an induction motor ?

c) A 11kW, 3 phase, 6 pole, 50 Hz, 220V star connected induction motor has 54 stator slots, each containing 9 conductors. Calculate the value of bar and end ring currents. The number of rotor bars is 64. The machine has an efficiency of 0.86 and a power factor of 0.85. The rotor mmf may be assumed as 85% of stator mmf. Also find the bar and end ring areas if the current density is $5A/mm^2$. 5 + 4 + 6

12. Determine the main dimensions, number of radial ventilating ducts, number of stator slots and the number of turns per phase of a 3.7 kW, 400 volt, 3 phase, 4 pole, 50 Hz SQIM to be started by star-delta starter.

    Assume :

    Average flux density in the gap = 0.45 Wb/m^2, ac = 23000, efficiency = 0.85, pf = 0.84

    Machine is rated at 3.7 kW. 4 poles are sold at a competitive price and therefore choose the main dimension to give a cheap design.

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

    b) Estimate the stator dimension, number of stator slots and number of stator conductors per slot for a 100 kW, 3.3 kV, 50 Hz, 12 pole star connected slip-ring induction motor.

    Assume :

    Average gap density = 0.4 Wb/m^2, specific electric loading = 25000A/m, efficiency = 0.9, power factor = 9.0 and winding factor = 0.96. Choose the main dimension to give best power factor. The slot loading should not exceed 500 ampere conductor.

5 + 10