Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(EE)/SEM-6/EE-601/2012

2012

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) Materials exhibiting zero value of resistivity are known as

a) conductors b) semiconductors

c) superconductors d) insulators.

ii) The maximum working temperature for class *B* type insulation is

a) 120°C b) 130°C

c) 155°C d) 180°C.

iii) Resistance elements of starters in electric motors are made of

a) constantan b) manganin

c) tungsten d) carbon.

iv) Transformer oil should have

a) low viscosity

b) low flash point

c) low dielectric strength

d) low dielectric constant.

v) Transformer tappings are provided on

a) LV side b) HV side

c) LV or HV side d) both (a) and (b).

vi) The desirable percentage of silicon in transformer core is

a) 0·4% b) 1%

c) 2% d) 4%.

vii) If E_t is volts/turn and $\in$ is pu leakage reactance of a transformer then

a) $\in \propto E_t$ b) $\in \propto E_t^2$

c) $\in \propto \frac{1}{E_t}$ d) $\in \propto \frac{1}{E_t^2}$.

viii) Air gap at the pole tips of a *dc* machine kept more than at the centre of the pole mainly to reduce

a) reactance voltage

b) effect of armature reaction

c) losses in armature cores

d) noise of the machine.

ix) Skewing is done in 3-phase induction motor to reduce

a) crawling

b) cogging

c) noise

d) time harmonic effect.

x) Pole shoes of *DC* machines are laminated to

a) reduce pulsation loss

b) reduce armature reaction

c) reduce iron weight

d) dissipate more heat.

xi) To avoid cogging in 3 ph, in 'p' pole squirrel cage induction motor having Z_1 number of stator slots and Z_2 number of rotor slots

a) $Z_1 - Z_2 = 2p + 1$ b) $Z_1 - Z_2 = 3p - 1$

c) $Z_1 - Z_2 = 3p + 1$ d) $Z_1 = Z_2$.

xii) The shaft of electric motors are generally supported in

a) cast iron bearing b) bush bearing

c) magnetic bearing d) ball or roller bearing.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Discus in brief the advantages of 'Standardisation' in electrical machine design. Write down the complete specification of a 3-phase induction motor. 2 + 3

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

b) Why does the core of a transformer require to be stepped while the yoke does not ? 3 + 2

4. For a given volume of total copper in a transformer, prove that the current density in primary and secondary winding should be equal in order to have minimum i^2r loss.

5. A plunger type magnet has to lift a mass of 200 kg from a distance of 5 mm. The area of pole face is $5 \times 10^{-3} m^2$. Find the current required if the exciting coil has 3000 turns. Assume that the mmf required for iron parts is 10% of airgap mmf. Neglect fringing.

6. Two rotors having identical number of slots and dimensions have their cages made of copper and aluminium respectively. Compare their performance regarding (i) full load slip (ii) starting torque (iii) temp rise. 2 + 2 + 1

GROUP – C
(Long Answer Type Questions)

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

7. a) Identify a few basic features that are to be considered for designing a power transformer and a distribution transformer.

   b) What is meant by the symbols 'ONAN' and 'OFWF' often used in transformer ?

   c) Determine the main dimensions of the core, the number of turns and the cross sections of the conductors for a 125 kVA, 6600/460 V, 50 Hz, single phase, coretype transformer. Given maximum flux density in core and yoke = 1·2 *T*, the current density = 2·5 A/mm^2, window space factor = 0·3, (height / width) ratio of window = 3 : 1, net cross-section of copper in the window = 0·225 times the net cross-section of iron in the core. Assume a square section for the assembled core allowing 10% for insulation between the laminations. 3 + 2 + 10

8. a) What do you mean by 'specific magnetic loading' and 'specific electric loading' as used in rotating electric machine design ? How do the class of insulation and operating speed affect the choice of specific loadings ?

b) Determine the main dimensions turns/ph, number of slots, conductor cross-section and slot area of a 250 HP, 3-phase, 50 Hz, 400 V, 1410 rpm, delta connected slip ring induction motor. Assume specific magnetic leading B_{aV} = 0·5 *T*, specific electric loading $\overline{ac}$ = 30,000 A/m, efficiency = 0·9, power factor = 0·9, winding factor = 0·955, current density = 3·5 A/mm^2, the slot space factor = 0·4, core length / pole pitch = 1·2. (2 + 3) + 10

9. a) Discuss how the effect of fringing flux is taken into account in airgap mmf calculation of rotating machines with open slots.

b) Calculate the mmf required for the airgap of a machine having core length of 0·32 m including 4 ducts of 10 mm each, pole arc = 0·19 m, slot pitch = 65·4 mm, slot opening = 5 mm, airgap length = 5 mm, flux/pole = 52 mwb. Given Carter's coefficient = 0·18 for the ratio of slot opening to gap length = 1 and is equal to 0·28 for the ratio of slot opening to gap length = 2. 5 + 10

10. a) Determine the leakage permeance per meter length of a rectangular semi-enclosed slot having the following dimensions : slot width = 10 mm, slot opening = 4·5 mm, height of conductor portion = 26 mm, height above the conductor and below wedge = 1 mm, wedge height = 3·5 mm, lip height = 1·5 mm.

Derive any formula you have used.

b) A transformer is designed with the ratio of window height to window width equal to 2. If this ratio is increased to 3 at design stage, explain its effect on the transformer cost, voltage regulation and efficiency.

10 + (2 + 2 + 1)

11. a) Discuss the major areas of application of resistors in different fields of electrical engineering. Cite examples.

b) Derive how Newton's Law of cooling can be utilised in designing heating wire elements.

c) A 240 V, 1·5 kW single element electric furnace utilises a nichrome resistance wire operating at 1000°C. Estimate a suitable length and diameter of the wire element. Take radiation efficiency = 92%, emissivity = 0·9 and resistivity of nichrome = 0·42 ohm–m at 1000°C. The ambient temperature = 30°C. 4 + 5 + 6