NEW SCHEME

EE62

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Sixth Semester B.E. Degree Examination, July/August 2005

Electrical & Electronics Engineering

Electrical Machine Design

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. Missing data, if any, can be suitably assumed.

1. (a) Classify the insulating materials based on thermal considerations. Give examples for each classification. (7 Marks)

   (b) What are the major considerations accounted for the good design of electrical machines. (5 Marks)

   (c) Derive the output equation of a d.c. machine. (8 Marks)

2. (a) Determine the main dimensions, number of poles, and length of air gap of a 600 kW, 500V, 900 rpm d.c. generator. Assume average gap density as $0.6 Wb/m^2$ and ampare conductors per meter as 35000. The ratio of pole arc to pole pitch is 0.75 and the efficiency as 91 per cent.

   The design limitations are :
   Peripheral speed not to exceed 40 m/sec
   Armature mmf/pole not to exceed 7500
   The mmf required for the air gap is 50 percent of armature mmf . kg=1.15.(12 Marks)

   (b) Explain the procedure for designing a shunt fluid coil for d.c. machine. (8 Marks)

3. (a) Calculate the approximate overall dimensions for a 200 kVA, 6600/440V, 50Hz, 3 phase core type transformer. The following data may be assumed :
   EMF per turn = 10V. Maximum flux density = 1.3 Wb/m^2. Current density = 2.5A $/mm^2$. Window space factor = 0.3 : overall height = overall width. Stacking factor = 0.9. Use a three stepped core. For a three stepped core, take $a = 0.9d$; $Ai = 0.6d^2$, with usual notations. (10 Marks)

   (b) Derive an expression for the leakage reactance of a transformer with primary and secondary cylindrical coils of equal length. State clearly the assumptions made. (10 Marks)

4. (a) Obtain an expression for the no load current of a single phase transformer. (5 Marks)

   (b) Write a short note on cooling of transformers. (5 Marks)

   (c) A single phase, 400V, 50 Hz transformer is made of stampings having a relative permeability of 1000. The length of flux path is 2.5 metres. The area of cross section of the core is $25 cm^2$ and the primary winding has 800 turns. Estimate the maximum flux and the no load current of the transformer. The iron loss at the working flux density is 2.6 W/kg. Iron weighs $7.8 \times 10^3\ kg/m^3$. (10 Marks)

Contd.... 2

5. (a) Derive the output equation of a three phase induction motor. (10 Marks)

(b) A 15 kW, 400V, 3 phase, 50 Hz, 6 pole induction motor has a diameter of 30cm and core length of 12cm. The number of stator slot is 72 with 20 conductors per slot. The stator is delta connected. Calculate the magnetising current per phase if the length of the air gap is 0.55mm. Assume gap contraction factor as 1.2. Assume, mmf required for the iron parts is 35 per cent of the air gap mmf coil span = 11 slots. (10 Marks)

6. (a) Explain the phenomenon 'Cogging and crawling' of 3 phase squirrel cage induction motor. What are the rules used to avoid cogging, crawling and hooks and cusps on the torque speed characteristic of the motor? (10 Marks)

(b) A 90 kW, 500V, 50Hz, 3 phase, 8 pole induction motor has a star connected stator winding kept in 63 slots with 6 conductors per slot. If the slip ring voltage on open circuit is to be 400V find a suitable rotor winding stating :

i) Number of slots

ii) Number of conductors per slot

iii) Coil span

iv) Slipping voltage on open circuit.

v) Full load current per phase in rotor.

Assume efficiency = 0.9. Power factor = 0.86. (10 Marks)

7. (a) Define short circuit ratio of a synchronous machine. What are its effects on the machine performance? (10 Marks)

(b) Determine the main dimensions for a 10 kVA, 3 phase, 400/230V, star connected 1500rpm, 50Hz, alternator. Assume B av=0.45T, q=22000 ac/m Winding factor = 0.96. Ratio of core length to pole pitch =1. Also determine the number of slots and conductors per slot. (10 Marks)

8. (a) The field coils of a salient pole alternator are wound with a single layer winding of bare copper strip 30mm deep, with separating insulation of 0.15 mm thick. Determine suitable winding length, number of turns and thickness of conductor to develop an mmf of 12000 amp turns with a potential difference of 5 V per coil and with a loss of $1200 W/m^2$ of total coil surface. The mean length of turn is 1.2m. The resistivity of copper is 0.021 ohm/m and mm^2. (10 Marks)

(b) Discuss the procedure for the design of the rotor of a single phase induction motor. (10 Marks)

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NEW SCHEME

EE62

Reg. No. | | | | | | | | | | |

Sixth Semester B.E. Degree Examination, January/February 2006

Electrical & Electronics Engineering

Electrical Machine Design

Time: 3 hrs.)

(Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. Any missing data may be suitably assumed.
3. Reference to design data hand book is permitted.

1. (a) Prove that in a d.c motor, torque is proportional to the volume of active material used. **(4 Marks)**

   (b) Discuss the different types of insulation materials used in electrical machines. Explain the statement.

   "Insulation decides the rating of the machines" **(4+4 Marks)**

   (c) Show that the output of a d.c. generator with a single coil is given by $\frac{.03E'V.qA}{P.N.}$ kW where E' is the average voltage between adjacent commutator segments

   V, the peripheral velocity in meters /sec

   q, the specific electric loading in ac/meter

   P is the number of poles

   N is the speed in rpm **(8 Marks)**

2. (a) Discuss the choice of number of poles used in a d.c machine. **(8 Marks)**

   (b) Calculate the main dimensions of a 20 H.P. 1000 rpm 400V d.c. motor. Average value of flux density = 0.37 tesla, specific electric loading = 16,000 AC/metre, Efficiency 90%.

   Choose a suitable pole number and justify the selection **(12 Marks)**

3. (a) Derive the output equation of a 3 phase core type transformer. **(8 Marks)**

   (b) Calculate the main dimensions for a 250 kVA 6600/415V, 50HZ, 3phase core type transformer.

   Assume the following data

   Emf/turn = 10V, maximum value of flux density = 1.1 tesla. Current density 2.5 A/mm^2, window space factor = 0.3. overall height = overall width, Stacking factor = 0.9. Use a 3 stepped core, the width of largest stamping is 0.9, Net iron area = $.6d^2$ where d = diameter of the circumscribing circle. **(12 Marks)**

4. (a) Derive an expression for the leakage reactance of the primary of a transformer. **(10 Marks)**

Contd.... 2

(b) A single phase, 240V, 50 H_Z transformer is built from stampings having a relative permeability of 1000. The length of flux path is 1.8m. the area of cross section of the core is 1.8×10^{-3} metre^2 and the primary winding has 650 turns. Estimate the maximum value of flux and the no load current of the transformer. The iron loss at working flux density is 2.6 watts/kg. Iron weighs 7.8×10^3 kg/metre ^{3}. Stacking factor 0.9. **(10 Marks)**

5. (a) A 8 pole , 500 V, d.c shunt generator, with all the field coils connected in series, requires a m.m.f of 5000 At/pole. The poles are of rectangular dimensions $120 \times 200mm^2$ and available winding area is $120 \times 25mm^2$. Determine :

i) the area of cross section of the wire

ii) Number of turns

iii) MMF supplied by the field.

A conductor of round cross section is used. Resitivity is $0.02\Omega - mm^2/metre$ and the insulation of the wire increases the diameter by 0.2mm. Allow a voltage drop of 50 volts in the field regulator. **(8 Marks)**

(b) Discuss the various factors which influence the selection of air gap, stator and rotor slots in an induction motor . **(3×4=12 Marks)**

6. (a) Derive the output equation of an induction motor. **(5 Marks)**

(b) Determine the main dimensions, turns/phase, no. of slots, conductor area and slot area in an induction motor. rated for 250 H.P 400V, 3ph, 1410 rpm (slipring induction motor) Assume $B_{average}$ = 0.5 Tesla, specific electric loading 30,000 AC/m. Efficiency 0.9, P.F. = 0.9, winding factor = 0.955. Current density = 3.5A/mm^2 Slot space factor = 0.4, Ratio of core length to pole pitch = 1.2. The machine is delta connected.

(15 Marks)

7. (a) What is a short circuit ratio in a synchronous machine? How does it influence the design of alternators? **(4+4 Marks)**

(b) Obtain the main dimensions of a 500 kVA 6600 volts, $50H_Z$, 12 pole star connected salient pole alternator giving the following details.

i) internal diameter ii) Length of the machine. No. of stator conductors /phase, B = 0.56 tesla. Sp electric loading = 26,000 AC/metre. Winding factor = 0.95. **(12 Marks)**

8. Write short notes on any FOUR :

a) Peripheral velocity and its influence on design of machines.

b) Cooling of transformers

c) Advantages of rotating field structure

d) Advantage of double cage rotors in induction machines.

e) Logging end crowling of 3 phase induction motor

f) Design of the stator of a single phase induction motor. **(4×5=20 Marks)**

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NEW SCHEME

Sixth Semester B.E. Degree Examination, July 2006
Electrical and Electronics Engineering
Electrical Machine Design

Time: 3 hrs.] [Max. Marks:100

Note: 1. ***Answer any FIVE full questions.***
2. ***Missing data may be suitably assumed.***
3. ***Use of design data hand book is permitted.***

1 a. Explain specific loadings and the usual range of values for each of the loading. **(05 Marks)**

b. Classify the insulating materials used in electrical machines based on thermal considerations. **(07 Marks)**

c. Explain the various factors that affect the choice of number of poles of a DC machine. **(08 Marks)**

2 a. Show that the output of a DC generator with single turn coil is given by,

$$P' = \frac{.03E'vqA}{PN} KW$$

Where E' = Average voltage between adjacent commutator segments,
v = Peripheral speed of the generator in m/sec,
P = Number of poles,
N = Speed in rpm. **(10 Marks)**

b. Calculate the diameter and the length of armature for a 7.5 KW, 4 pole, 1000 rpm, 220 V shunt motor.
Given : Full load efficiency = 0.83, Maximum gap flux density = 0.9 wb/m^2, Specific electric loading = 30,000 AC/meter, field form factor = 0.7. Assume that the maximum efficiency occurs at full load and the field current is 2.5% of rated current. The pole face is square. **(10 Marks)**

3 a. During the design of armature of a 1000 KW, 500 V, 10 pole, 300 r.p.m DC compound generator, following information has been obtained i) External diameter of armature 1.4 m ii) Gross core length 0.35 m iii) flux per pole 0.105 wb. Based on the above design information, find out the following details of the field system, i) Axial length of pole ii) Width of pole iii) Height of the pole iv) Pole arc. **(12 Marks)**

b. Prove that EMF/turn of a single phase transformer = $K\sqrt{Q}$, where Q = per phase KVA output of transformer. **(08 Marks)**

4 a. Derive an expression for the leakage reactance of a transformer with primary and secondary cylindrical coils of equal length, stating clearly the assumptions made. **(10 Marks)**

Contd....2

4 b. Calculate the active and reactive components of no load current of a 400 V, 50 Hz, single phase transformer having the following particulars:
Stacking factor = 0.9 ; Density = 7.8 x 10^3 kg/m^3 ; Length of mean flux path 2.2 m ; Gross iron section = 100 cm^2 ; Primary turns 200 ; Joints equivalent to 0.2 mm of air gap. Use the following data : **(10 Marks)**

Bm (wb/m^2)	0.9	1.0	1.2	1.3	1.4
MMF(AT/m)	130	210	420	660	1300
Iron loss (Watts/kg)	0.8	1.3	1.9	2.4	2.9

5 a. The full load efficiency of a 300 KVA transformer is 98.2% at unity power factor. Design the number of cooling tubes necessary, if the temperature rise is 35°C. The tank area may be assumed as 4.92 m^2. Assume tube diameter as 5 cm and average length as 105 cm. Heat dissipation may be assumed as 12.5 w/m^2/°C. **(10 Marks)**

b. Deduce for a 3 phase induction motor an expression showing the relationship between its output, the main dimensions, specific electric and magnetic loading, efficiency and power factor. **(10 Marks)**

6 a. Discuss the various factors that affect the choice of the length of the air gap of an induction motor. **(10 Marks)**

b. Estimate the stator core dimensions, number of slots and number of stator conductors per slot for a 100 KW, 3300 V, 50 Hz, 12 pole star connected slip ring induction motor.
Assume: Average gap density=0.4 Tesla, Conductors per meter =25,000 A/m
Efficiency = 0.9, Power factor = 0.9 and Winding factor = 0.96. Choose main dimensions to give best power factor. The slot loading should not exceed 500 Ampere conductor. **(10 Marks)**

7 a. What is meant by the terms crawling and cogging in case of a 3 phase induction motors? What steps are taken in the design procedure to minimize these tendencies? **(08 Marks)**

b. A 3 phase, 3000 volts, 260 KW, 50 Hz, 10 pole squirrel cage induction motor gave the following results during the preliminary design,
Internal diameter of stator = 75 cm,
Gross length of stator = 35 cm,
Number of stator slots = 125
Number of conductors / slot = 10
Based on the above data, calculate the following for the squirrel cage rotor,
i) Total losses in the rotor bars.
ii) Losses in the end rings.
iii) Equivalent resistance of rotor in terms of stator. **(12 Marks)**

8 a. Explain the various factors to be considered while selecting the number of slots in the stator of a 3 phase synchronous machine. **(08 Marks)**

b. Explain short circuit ratio of a synchronous machine. What are its effect on the performance of the synchronous machine? **(06 Marks)**

c. Determine the main dimensions for a 1000 KVA, 50 Hz, 3 phase, 375 rpm alternator. The average air gap flux density is 0.55 wb/m^2 and the ampere conductors per meter is 28,000. Use rectangular poles and assume a suitable value for the ratio of core length to pole pitch. The maximum permissible peripheral speed is 50 m/sec. The run away speed is 1.8 times the synchronous speed. **(06 Marks)**

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EE62

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NEW SCHEME

Sixth Semester B.E. Degree Examination, Dec.06 / Jan.07
Electrical & Electronics Engineering
Electrical Machine Design

Time: 3 hrs.] [Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Electrical machine design data hand book is permitted.

1 a. Explain clearly the factors which impose limitations in the design of electrical machines. **(05 Marks)**

b. Classify the electrical insulating materials as per IS No. 1271 – 1958 with examples and show how, the life of electrical insulation gets shortened by increase in temperature beyond its limit. **(05 Marks)**

c. Determine the main dimensions, number of poles and the length of air gap of a 600 kW, 500 V, 900 rpm dc generator. The average gap density is 0.6 wb/m^2 and 'ac' per meter is 35000. The ratio of pole arc to pole pitch is 0.75 and the efficiency is 91%. Assume square pole face. Use the following design constraints for check: peripheral speed $\leq$ 40 m/s, frequency of flux reversals $\leq$ 50 Hz, current per brush arm $\leq$ 400 A and armature mmf per pole $\leq$7600 A. The mmf required for air gap is 50% of armature mmf and gap contraction factor is 1.15. **(10 Marks)**

2 a. A 10 Kw, 500 V, 8 pole, dc shunt generator requires an mmf of 5000 A per pole for its field excitation. The pole body is rectangular with cross section 120 × 120 mm^2. The winding is 120 mm in height and 25 mm in depth. The round copper wire used for field winding has an insulation covering of 1 mm thickness. Take resistivity of copper as 0.02 Ω/m and mm^2. Allow a voltage drop of 50 V in the field regulator. Determine :

i) The cross-sectional area of field conductor,
ii) The number of turns,
iii) The loss dissipation in the field coil in W/m^2 considering outside, top and bottom surfaces only. **(08 Marks)**

b. A 500 kW, 460 V, 8 pole, 375 rpm dc compound generator has an armature diameter of 1.1 m and a core length of 0.33 m. The 'ac' per meter is 34000. The internal voltage drop is 4% of terminal voltage. The field current is 1% of output current. The ratio of pole arc to pole pitch is 0.7. The voltage between adjacent commutator segments at no load should not exceed 15 V and the slot loading should not exceed 1500 A. The diameter of commutator is 0.65 of armature diameter and the minimum allowable pitch of commutator segment is 4 mm. Suggest suitable type of armature winding. Find the number of slots, number of coils, number of commutator segments, number of conductors per slot and the number of turns per coil in the winding. **(12 Marks)**

3 a. Derive the output equation of 3 phase core type transformer and hence deduce the expression of output – emf per turn. **(10 Marks)**

Contd...2

3 b. Calculate the approximate overall dimensions of 200 KVA, 6600 / 440 V, 50 Hz, 3 phase core type transformer. The following data may be assumed:
emf per turn =10 V, maximum flux density=1.3 Wb/m^2, current density=2.5 A/mm^2, window space factor = 0.3, overall height = overall width, stacking factor = 0.9.
Use 3 stepped core. Width of largest stamping = 0.9 d and net iron area = $0.6d^2$ where d is the diameter of circumscribing circle. **(10 Marks)**

4 a. Derive an expression for the number of cooling tubes required to limit the temperature rise in a 3 phase transformer. Design its tank dimensions and show them pictorially. **(10 Marks)**

b. A 15000 kVA, 33/6.6 kV, 3 phase star/delta, core type transformer has the following data:
Net iron area of each limb = 0.15 m^2, net area of yoke = 0.18 m^2, mean length of flux path in each limb = 2.3 m, mean length of flux path in each yoke = 1.6 m, number of turns in hv winding = 450, density of iron = 7.8 × 103 kg/m^3. Calculate the no load current. Use the following table. **(10 Marks)**

$B_m Wb/m^2$	0.9	1.0	1.2	1.3	1.4
Mmf A/m	130	210	420	660	1300
Iron loss W/kg	0.8	1.3	1.9	2.4	2.9

5 a. Derive the output equation of 3 phase induction motor and explain the factors which influence the choice of specific magnetic and specific electric loading. **(10 Marks)**

b. A 90 kW, 500 V, 50 Hz, 3 phase, 8 pole induction motor has star connected stator winding accommodated in 63 slots with 6 conductors per slot. If the slip ring voltage on open circuit is to be about 400 V, find
i) Number of slots.
ii) Number of conductors per slot.
iii) Coil span.
iv) Slip ring voltage on open circuit.
v) Approximate full load current per phase in rotor. Assume efficiency = 0.9; power factor = 0.86. **(10 Marks)**

6 a. Explain the factors which influence the length of air gap of 3 phase induction motor and write few emphirical formulae for the length of air gap. **(10 Marks)**

b. A 15 kW, 400 V, 3 phase, 50 Hz, 6 pole induction motor has stator bore diameter of 0.3 m and core length of 0.12 m. The number of slots is 72 with 20 conductors per slot. The stator is delta connected. Calculate the value of magnetizing current per phase if the length of air gap is 0.55 m. The gap contraction factor is 1.2. Assume that mmf required for iron parts to be 35% of the air gap mmf. Coil spin = 11 slots. **(10 Marks)**

7 a. Define the short circuit ratio of synchronous machine and explain the effect of SCR on machine performance. **(04 Marks)**

b. Explain the factors to be considered in the selection of number of armature slots of synchronous machine. **(04 Marks)**

Contd...3

7 c. A 2500 kVA, 2400 V, 225 rpm, 3 phase, 60 Hz, star connected salient pole alternator has the following design data :
Stator bore = 2.5 m; core length = 0.44 m; slot pole per phase = 3.5 ; conductors per slot = 4; circuits per phase = 2; leakage factor = 1.2; winding factor = 0.95. The flux density in pole core is 1.5 Wb/m^2, the winding depth is 30 mm, the ratio of full load field mmf to armature mmf is 2, field winding space factor is 0.84 and the field winding dissipates 1800 W/m^2 of inner and outer surface without the temperature rise exceeding the permissible limit. Leave 30 mm for insulation, flanges and height of pole shoe along the height of pole. Find

i) The flux per pole.
ii) Length and width of pole.
iii) Winding height and
iv) Pole height.

(12 Marks)

8 Answer any four of the following :

a. Design the rotor of non salient synchronous machine.
b. Design the rotor of single phase induction motor.
c. Design the end ring of 3 phase squirrel cage induction motor.
d. Design the slot dimensions of dc machine and show the slot insulation details.
e. Explain what is leakage reactance and state the assumptions made in the calculations of leakage reactance of core type transformer. **(20 Marks)**

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EE62

Sixth Semester B.E. Degree Examination, Dec. 07 / Jan. 08
Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note :1. ***Answer any FIVE full questions.***
2. ***Suitable values may be assumed for any missing data.***
3. ***Draw figures wherever necessary.***

1 a. Show that the output of a dc generator with single turn coils is given by the expression $S = \frac{0.03E'\upsilon qA}{PN}$
Where E' = average voltage between adjacent commutator segments.
υ = Peripheral velocity of the rotar in meters/sec
P = Number of poles, N = Speed in rpm and
q = Specific electric loading. **(08 Marks)**

b. Design a 50 KW, 4 pole, 600 rpm dc shunt generator, the full load terminal voltage being 220 V. If the maximum gap density is 0.83 webers/m^2 and the armature ampere conductors per metre are 30000 calculate the suitable dimensions of armature core to give a square pole face. Assume that the full load armature drop is 3% of the rated terminal voltage and that the field current is 1% of the full load current. Ratio of pole arc to pole pitch is 0.67. **(12 Marks)**

2 a. Calculate the main dimensions of a 20 HP, 1000 rpm, 400 V, dc motor Bar = 0.37 Wb/m^2, Specific electric loading = 16000 ac/m. Assume an efficiency of 90%. **(10 Marks)**

b. A shunt field coil has to develop an mmf of 9000 AT, the voltage drop in the field coil is 40 V and the resistivity of round wire is 0.021 $\Omega m/mm^2$. The depth of winding is 35 mm and length of mean turn is 1.4 m. Design a coil so that the power dissipated is 700 watts/m^2 of the total coil surface. Take the diameter of insulated wire to be 0.2 mm greater than bare wire. **(10 Marks)**

3 a. Prove that EMF/turn of a three phase transformer is given by $K\sqrt{Q}$ where Q is the output/phase of the transformer. **(05 Marks)**

b. Show that the losses in a transformer are proportional to the cube of its linear dimensions. **(05 Marks)**

c. A single phase 400 V, 50 Hz transformer is built from stampings having a relative permeability of 1000. The length of flux path is 2.5 m. Area of cross section of the core is 2.5×10^{-3} m^2 and the primary winding has 800 turns. Estimate the maximum flux and no load current of the transformer. Iron loss at the working flux density is 2.6 W/kg. Iron weighs 7.8×10^3 kg/m^3 . Stacking factor = 0.9 **(10 Marks)**

4 a. Derive an expression for the leakage reactance of a transformer with primary and secondary coils of equal length. **(08 Marks)**

4 b. Calculate the overall dimensions for a 200 kVA, 6600/440 V, 50 Hz, 3 phase core type transformer assuming the following data:
EMF / turn = 10 volts
Maximum flux density = 1.3 Wb/m^2,
Current density = 2.5 A/m^2,
Window space factor = 0.3
Overall height = Overall width
Stacking factor = 0.9
Use a 3 stepped core,
Net core area = 0.6 d^2
Where d is the diameter of the circumscribing circle.
Width of largest stamping = 0.9 d **(12 Marks)**

5 a. Discuss the factors to be considered while deciding the length of air gap, number of stator and rotor slots. **(08 Marks)**

b. Estimate the stator core dimensions, number of stator slots and number of stator conductors per slot for a 100 kw, 3300 V, 50 Hz, 12 pole, star connected slip-ring induction motor. Assume an average gap density of 0.4 w/m^2 ampere conductors/metre = 25000. Efficiency = 90%, Power factor = 0.9 and the winding factor = 0.96. Choose the main dimensions to give best p.f. The slot loading must not exceed 500 ac. **(12 Marks)**

6 a. A 3 phase, 4 pole, 50 Hz induction motor has 24 stator slots and 28 rotor slots. Prove that it has a tendency to run as a synchronous motor at 214.3 rpm. **(08 Marks)**

b. A 90 kW, 500 V, 50 Hz, 3 phase 8 pole induction motor has a star connected stator winding accommodated in 63 slots with 6 conductors/slot. If the slip ring voltage on open circuit is to be above 400 V, find a suitable rotor winding stating
i) Number of slots.
ii) Number of conductors/slot
iii) Coil span
iv) Approximate full load current/phase in rotor.
Assume efficiency = 0.9, p.f = 0.86 **(12 Marks)**

7 A 1000 KVA, 3300 V, 300 rpm, 3 phase alternator has 180 volts with 5 conductors/slot, single layer winding with full pitch coils. The winding is star connected with one circuit per phase. Determine the specific electric and magnetic loadings if the stator bore is 2.0 meters and the core length is 0.4 meters. Using the same loadings determine the corresponding data for a 1250 kVA, 3300 V, 50 Hz, 250 rpm, 3 phase star connected alternator having 2 circuits per phase. The machine has 60° phase spread. **(20 Marks)**

8 Write short notes on any four:
a. Slot insulation in d.c. machines.
b. Cooling of transformers.
c. Crauling and cogging in induction motor.
d. Choice of air gap for d.c. machines.
e. Design of end rings for squirrel cage machines.
f. Stator design for single-phase induction motor. **(20 Marks)**

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EE62

Sixth Semester B.E. Degree Examination, June / July 08

Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. What are the major considerations to be accounted for the good design of electrical machines? **(05 Marks)**

b. Enumerate the required properties of the magnetic materials used for the manufacture of electric machines. **(05 Marks)**

c. List any four insulating materials used in electrical machines specifying their thermal class. **(04 Marks)**

d. Derive the output equation of D.C. machine. **(06 Marks)**

2 a. Discuss the various factors which govern the choice of number of poles in D. C. machines. **(10 Marks)**

b. Determine the main dimensions; best number of poles; length of air gap for a 600 kW; 500 V; 900 rpm DC generator. Assume the average gap density as 0.60 ub /m^2 and ampere conductor loading 35,000. The ratio of pole arc to pole pitch is 0.75 and the efficiency is 91%. The peripheral speed is to be below 40 m /sec and the armature mmf per pole to be below 7500 A. The mmf required for air gap is 50% of armature mmf; Gap contraction factor = 1.15. **(10 Marks)**

3 a. Show that –

i) For minimum cost design of transformer, cost of iron = cost of conductor

ii) For minimum copper loss current density in primary winding = current density in secondary winding. **(10 Marks)**

b. A 250 KVA 6600 /440 V; 50 c/s; 3 phase, star /delta core type oil immersed natural cooled transformer gave the following results during the design calculations. Length of the core plus twice the height of the yoke = 85 cm
centre to center distance of the core = 32 cm
outside diameter of the HV winding = 31 cm
total iron losses = 1500 watts
copper losses in the LV winding = 1200 watts
copper losses in the HV winding = 2050 watts

Calculate :

i) The dimensions of the tank

ii) Temperature rise of the transformer

iii) Number of tubes if the temp rise is not to exceed 35^0 C

Assume clearances at the base and top = 500 mm
clearances lengthwise = 10 mm
clearances along width wise = 15 mm.
Length of cooling tube = 1.35 m, diameter of tube = 50 mm. **(10 Marks)**

4 a. Derive an expression for the no load current of a 3 –phase transformer. **(05 Marks)**

b. Show that for a stepped core

$$\text{Ratio} \frac{\text{Net core area}}{\text{Area of circum scribing circle}} = 0.71.$$ **(07 Marks)**

c. The window of a 50 KVA; 1 – phase, core type transformer has an area of 340 cm^2. The window space factor is 0.35; maximum flux density in the core is 1.0 Wb /m^2 and average current density can be taken as 2.1 A /mm^2, core area factor $K_C = 0.56$.

Estimate :

i) Cross sectional are a of the core

ii) Diameter of the core circle if cruciform section core is used

iii) Window dimensions if the distance between core centers = (2) (width of largest stampings)

iv) Dimensions of the frame. **(08 Marks)**

5 a. Explain the factors to be considered while selecting length of air gap in induction motor. **(10 Marks)**

b. A 1.1 kW; 3 – phase; 50 Hz; 1500 synchronous rpm delta connected induction motor has a stator bore of D = 0.15 m and core length L = 0.06 m. Estimate the main dimensions of a 3.7 kW; 3 –phase 50 Hz; 1000 syn rpm delta connected motor having the same loadings as the previous one. The efficiency and power factors also remain same. Assume same value of $\frac{L}{\tau}$ ratio. **(10 Marks)**

6 a. Give the procedure of estimating end ring current in a 3 – phase squirrel cage rotor, with sketch. **(10 Marks)**

b. A 3 –phase; 50 Hz; 6 – pole; star connected slip ring induction motor has flux per pole as 0.0124 Wb. and voltage between slip rings as 200 V. Determine :

i) Number of stator slots

ii) Number of rotor slots

iii) Number of rotor conductors per slot

Assume rotor slots to be 3 – slots per pole pair less than stator slots and Kwr = 0.95. Give stator core diameter = 0.4 m. **(10 Marks)**

7 a. Define short circuit ratio and explain effects on the design of an alternator. **(10 Marks)**

b. A 500 KVA; 3.3 KV; 50 Hz; 600 rpm; 3 – phase salient pole alternator has 180 turns per phase. Estimate the length of air gap if the average flux density is 0.54 ub /m^2; the ratio of pole arc to pole pitch 0.66; the SCR 1.2; The gap contraction factor 1.15; winding factor 0.955. The mmf required for gap is 80% of no load field mmf and the winding factor 0.955. **(10 Marks)**

8 a. Derive an expression for the output equation of a single phase induction motor. **(06 Marks)**

b. Explain the various factors considered for the selection of armature slots of a 3 – phase synchronous machine.

c. Find the main dimensions of a 2500 KVA; 187.5 rpm 50 Hz; 3 –phase; salient pole synchronous generator. The generator is to be vertical water wheel type. The specific magnetic loading is 0.6 ub /m^2 and the specific electric loading is 34,000 A /m. Use circular poles with ratio of core length to pole pitch = 0.65. Specify the type of pole construction used if the runaway speed is about 2 times the normal speed. **(10 Marks)**

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06EE63

Sixth Semester B.E. Degree Examination, June-July 2009
Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note: 1.*Answer any FIVE full questions, selecting at least TWO questions from each part.*
2.Design data book may be used if necessary.

PART – A

1 a. Explain clearly the factors which impose limitations in the design of electrical machines. **(06 Marks)**

b. Define specific loadings for D.C machines and what are the merits and demerits of selecting higher values of specific loadings. What are the factors to be considered during the choice of specific loading? **(07 Marks)**

c. Discuss the various factors which govern the choice of number of poles in D.C machines. **(07 Marks)**

2 a. A 250 kW, 500V, 600 rpm, d.c. generator is built with an armature diameter of 75cm and a core length of 30cm. The lap connected armature has 720 conductors using the data obtain form this machine determine the armature diameter, core length, number of armature slots, armature conductors and conductors per slot for a 350 kW, 440V, 720rpm, 6 pole d.c. generator. Assume a square pole face with ratio of pole arc to pole pitch equal to 0.7. The full load efficiency is 0.91 and the internal voltage drop is 4 percent of rated voltage. Take slot pitch for 350 kW d.c. generator is 2.5cm. **(12 Marks)**

b. The following particulars refer to the shunt field coil for a 440V, 6 pole d.c. generator.

mmf per pole	= 7000 AT
depth of winding	= 50 mm
length of inner turn	= 1.1 m
length of outer turn	= 1.4 m
loss radiated from outer surface excluding ends	= 1400 W/m^2
space factor	= 0.62
resistivity	= 0.02 ohm per m/mm^2

Calculate : i) The diameter of wire ii) Length of coil
iii) No. of turns iv) Exciting current **(08 Marks)**

3 a. Show that EMF/turn of a three phase transformer is given by $E_t = K\sqrt{KVA/phase}$ and write a brief note on factors affecting the value of K. **(10 Marks)**

b. Calculate :
i) Net cross section of core ii) Gross area of the core
iii) Core dimensions iv) Window area
v) Dimensions of the window for 200 KVA, 6600/250V 1 ϕ shell type oil immersed self coded, distribution transformer based on the following design parameters.

Window space factor	= 0.28
Maximum flux density on the core	= 1.1 Tesla
Average current density	= 2.2A/mm^2 = 2.2×10^6 A/m^2
Window proportion	= 2.5 : 1
Reactangular core proportion	= 1.8 : 1

Net cross section of copper in the window is 0.2 times net cross section of iron in the core.
Assume stacking factor = 0.9

(10 Marks)

4 a. Derive an expression for leakage reactance of 1 ϕ core type transformer with primary and secondary coils of equal length. State clearly the assumptions made. **(12 Marks)**

b. Design the suitable number of coding tubes necessary for a 3 phase transformer having the following particulars :
KVA rating = 500 ; Efficiency 98% at 0.88 p.f ; Heat dissipiation = 12.5 watts/$m^2/^0C$; Tank Dimensions = 48cm x 96cm x 150cm. Assume the diameter of cooling tubes as 6cm and average height is 120cm. **(08 Marks)**

PART – B

5 a. Calculate the following design information for a 30kW, 440V, 3ϕ, 6 pole 50H_z delta connected sequirrel cage induction motor :
i) Main dimensions of stator frame ii) No. of turns per phase on stator winding
iii) No. of stator slots iv) No. of conductor per slot
Assume B_{ave} = 0.48 Tesla ; q = 26,000 ac/m ; Full load efficiency = 88% ; Full load power factor = 86%. Assume winding factor = 0.955. **(10 Marks)**

b. Explain the factors which influence the length of air gap of 3 phase induction motor and write few empherical formulae for the length of air gap. **(10 Marks)**

6 a. A 11kW, 3 phase , 6 pole 50 H_z 220V star connected induction motor has a 54 stator slots, each containing a conductors. Calculate the value of bar and end rising currents. The number of rotor bars is 64. The machine has an efficiency of 86% and power factor of 85%. The rotor mmf may be assumed as 85% of the stator mmf. Also find the bar and end ring sections if the current density is 5 A/mm^2. **(10 Marks)**

b. A 5 HP, 4 pole , 3ϕ induction motor works on a 50H_z , 400 volts mains. It is designed for Y- Δ starting and has following design data :
Rotor diameter = 14 cm ; Gross core length= 11.5 cm ; Turns per phase on stator = 360 ; Air gap length = 0.4 mm ; Winding factor = 0.955 ; Iron factor = 0.95 ; Carters gap – contraction coefficient = 1.25
Assume that the ampere-turns required for the iron parts are about 30% of that required for the gap. Calculate the magnetizing current. **(10 Marks)**

7 a. From first principles, derive the output equation of a 3-phase alternator in terms of specific loadings, diameter and length of the stator core. What are the usual values of specific loadings? **(10 Marks)**

b. During the design of stator of 3 phase, 7.5 KVA, 6.6 KV, 50H_z, 3000 rpm, turbo generator, following information have been obtained.
Internal diameter of stator = 0.75 m ; Gross length of core = 0.9 m ; Number of stator slots per pole per phase = 7 ; Sectional area of stator conductor = 190 mm^2 ; Number of conductor per slot = 4. Based on the above data, calculate the following:
i) Flux per pole ; ii) Specific magnetic loading ;
iii) Specific electrical loading iv) Current density for the stator winding. **(10 Marks)**

8 a. Define short circuit ratio in connection with 3 phase synchronous generator. Explain the factors affecting by short circuit ratio. **(10 Marks)**

b. Find the main dimensions of a 2500KVA, 187.5 rpm 50H_z, 3-phase, salient pole synchronous generator. The generator is to be vertical water wheel type. The specific magnetic loading is 0.6 ω b/m^2 and the specific electric loading is 34,000 AC/m, use circular poles with ratio of core length to pole pitch = 0.65. specify the type of pole construction used if the run away speed is about two times the normal speed. **(10 Marks)**

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