

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: EE409

Course Name: ELECTRICAL MACHINE DESIGN

Max. Marks: 100

Duration: 3 Hours

PART A

Answer all questions, each carries 5 marks.

		Marks
1	List five types of enclosures used in electrical machines.	(5)
2	Derive the output equation of a single phase core type transformer.	(5)
3	Define specific magnetic loading? Explain the factors need to be considered for choice of specific magnetic loading in a dc machine	(5)
4	Write short notes on (i) Short circuit ratio (ii) Run away speed.	(5)
5	How do you separate 'D' and 'L' from the volume D^2L of a 3 phase induction motor?	(5)
6	Explain the rules for selecting number of rotor slots in a three phase induction motor.	(5)
7	What is meant by discretization in finite element method?	(5)
8	Explain the hybrid techniques available for computer aided design.	(5)

PART B

Answer any two full questions, each carries 10 marks.

9	a) Examine the different types of ventilations in electrical machines.	(4)
	b) Derive the gap contraction factor for slots.	(6)
10	Determine the dimensions of core and yoke for a 100KVA 50Hz single phase core type transformer. A square core is used with distance between the adjacent limbs equal to 1.6 times the width of laminations. Assume Emf/turn 14V, Maximum flux density 1.1 Wb/m^2 , current density 3 A/mm^2 , window space factor 0.32, stacking factor 0.9. Flux density in the yoke to be 80% of flux density in the core.	(10)
11	a) Explain the procedure to calculate MMF for air gap and teeth in an electrical machine.	(5)
	b) Derive the volt per turn equation of a single phase transformer.	(5)

PART C

Answer any two full questions, each carries 10 marks.

12	a) Explain in steps how to separate D and L for a DC machine?	(3)
	b) Find out the main dimensions of a 50kW, 4 pole, 600 rpm DC shunt generator to give a square pole face. The full load terminal voltage being 220 V. The maximum gap density is 0.83 Wb/m^2 and the ampere conductors per meter is 30000. Assume that full load armature voltage drop is 3 per cent of rated terminal voltage and that the field current is 1 per cent of rated full load	(7)

- current. Ratio of pole arc to pole pitch is 0.67.
- 13 a) Distinguish between cylindrical pole and salient pole construction. (3)
b) Determine the main dimensions of a 2500 kVA 187.5 rpm, 50Hz 3 phase 3 kV, salient pole synchronous generator. The generator is to be a vertical, water wheel type. The specific magnetic loading is 0.6 wb/mm^2 and the specific electric loading is 34000 A/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 2 times the normal speed. (7)
- 14 a) Explain the design procedure of interpoles in DC machines? (5)
b) Determine the main dimensions of a 500 kVA, 50Hz 3 phase alternator to run at 375 rpm. The average air gap flux density is 0.55 wb/mm^2 , the specific electric loading is 25000 A/m . The peripheral speed should not exceed 35 m/sec . (5)

PART D

Answer any two full questions, each carries 10 marks.

- 15 (a) With all details of the various parameters including the units derive the output equation of a 3 phase squirrel cage induction motor. (5)
(b) Design the main dimensions of a 25 kW, 3 phase, 415V, 50 Hz, 1475 rpm squirrel cage induction motor having an efficiency of 85 % and full load power factor of 0.86. Assume $B_{av} = 0.5 \text{ T}$, $a_c = 28000 \text{ A/m}$. The rotor peripheral velocity is 25 m/s at synchronous speed. (5)
- 16 a) Explain how finite element method is used for analysis of electrical machines. (6)
b) List out the advantages of FEM based methods over conventional design procedures. (4)
- 17 a) Explain the procedure for separation of D and L from D^2L product while designing induction motors. (5)
b) What is computer aided design? How does it help in designing electrical machines? (5)

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

Course Code: EE409

Course Name: Electrical Machine Design

Max. Marks: 100

Duration: 3 Hours

PART A

Answer all questions, each carries 5 marks.

Marks

- | | | |
|---|---|-----|
| 1 | What is meant by hot spot rating in electrical machines? | (5) |
| 2 | Compare the reluctance of slotted armature with that of smooth armature surface. | (5) |
| 3 | Derive the output equation of DC machine. | (5) |
| 4 | Explain different types of cooling systems used in synchronous machines. | (5) |
| 5 | List out and explain the factors to be considered for selection of specific electric loading in 3-phase induction motors. | (5) |
| 6 | State the main constructional differences between cage induction motor and slip ring induction motor. | (5) |
| 7 | Explain synthesis method for computer aided design of electrical machines | (5) |
| 8 | Explain on few softwares used for designing electrical machines? | (5) |

PART B

Answer any two full questions, each carries 10 marks.

- | | | |
|----|---|-----|
| 9 | a) Examine any four components of armature leakage flux. | (4) |
| | b) Derive the relation between real and apparent flux densities. | (6) |
| 10 | a) Derive the output equation for 3 phase core type transformer. | (4) |
| | b) Determine the dimensions of core and yoke for a 200KVA 50Hz single phase core type transformer. A cruciform core is used with distance between adjacent limbs equal to 1.6 times width of core laminations. Assume voltage per turn 14 V, maximum flux density 1.1 Wb/m^2 , window space factor 0.32, current density 3 A/mm^2 and stacking factor 0.9. The net iron area is $0.56d^2$ in a cruciform core where d is the diameter of circumscribing circle and width of largest stamping is $0.85d$. | (6) |
| 11 | a) Explain unbalanced magnetic pull in rotating electrical machines. | (5) |
| | b) Derive the ratio of gross core area to area of circumscribing circle for a square core of a transformer. | (5) |

PART C

Answer any two full questions, each carries 10 marks.

- 12 a) Explain the flux pulsation produced in dc machine. (5)
b) Explain step by step design procedure of brushes and commutator in a DC machine. (5)
- 13 Find the main dimensions of a 100 MVA, 11kV, 50 Hz, 150 rpm, 3 phase water wheel generator. The average gap density is 0.65 Wb/m^2 and the ampere conductors per meter is 40000. The peripheral speed should not exceed 65m/s at normal running speed in order to limit the run away peripheral speed. Assume the winding factor to be 0.955. (10)
- 14 a) Explain step by step design procedure for armature of a dc machine. (5)
b) Find the main dimensions of a 2500 kVA, 187.5 rpm, 50 Hz, 3 phase, 3 kV, salient pole synchronous generator. The generator is to be vertical, water wheel type. The specific electric loading is 34000 A/m and B_{av} is 0.6 Wb/m^2 . Use circular poles with ratio of core length to pole pitch to be 0.65. Specify the type of pole construction used if the run-away speed is about 2 times the normal speed. (5)

PART D

Answer any two full questions, each carries 10 marks.

- 15 a) How do the iron losses affect selection of B_{av} ? (5)
b) Explain cogging and crawling in 3-phase induction machines. (5)
- 16 a) Explain on Analysis method of solving electrical machine using CAD with a flow chart. (6)
b) What are the advantages of analysis method? (4)
- 17 a) Design the main dimensions of a 25 kW, 3 phase, 415V, 50 Hz, 1475 rpm squirrel cage induction motor having an efficiency of 85 % and full load power factor of 0.86. Assume $B_{av} = 0.5T$, $a_c = 28000A/m$. The rotor peripheral velocity is 25 m/s at synchronous speed. (5)
b) Explain the steps involved in the computer aided design and analysis of electrical machines. (5)

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

Course Code: EE409

Course Name: Electrical Machine Design

Max. Marks: 100

Duration: 3 Hours

PART A

Answer all questions, each carries 5 marks.

Marks

- | | | |
|---|--|-----|
| 1 | Briefly explain the different types of enclosures used in electrical machines. | (5) |
| 2 | Give two differences between power transformer and distribution transformer. | (5) |
| 3 | Explain in steps the design of series field winding for a DC machine. | (5) |
| 4 | Salient pole alternators are not suitable for high speeds. Why? | (5) |
| 5 | State and explain the factors considered for selection of air gap length in induction motors. | (5) |
| 6 | List and justify the advantages of a larger air gap in induction motor. | (5) |
| 7 | List out and explain the features of three finite element based softwares for analysis of electrical machines. | (5) |
| 8 | Explain the basic concept of computer aided design. | (5) |

PART B

Answer any two full questions, each carries 10 marks.

- | | | |
|----|---|------|
| 9 | Explain the procedure to calculate MMF for air gap and teeth in an electrical machine. | (10) |
| 10 | a) Write the design equations to find the area of cross section of conductor for both primary and secondary of a transformer. (3) | (3) |
| | b) Determine the dimensions of core and window for a 5kVA, 50Hz, single phase core type transformer. A rectangular core is used with long side twice as long as short side. The window height is three times the width. Volt per turn is 1.8V, window space factor is 0.2, current density is 1.8A/mm ² and maximum flux density is 1Wb/m ² . (7) | (7) |
| 11 | a) A 15kW 230V 4 pole dc machine has the following data. (7) | (7) |
| | Armature diameter 0.25m, armature core length 0.125m, length of air gap at pole centre 2.5mm, flux per pole 11.7 mWb, Ratio of pole arc to pole pitch 0.66. Calculate the mmf required for air gap if (i) armature surface is treated as smooth (ii) armature is slotted and the gap contraction factor is 1.18. | |

- b) Examine the factors that influence the choice of flux density of a transformer. (3)

PART C

Answer any two full questions, each carries 10 marks.

- 12 a) Differentiate between square pole face and rectangular pole face. (3)
- b) A 4 pole 25hp, 500 V, 600 rpm DC series motor has an efficiency of 82%. The pole faces are square and the ratio of pole arc to pole pitch is 0.67, $B_{av}=0.55$ Wb/m², $a_c=17000$ A/m. Obtain the main dimensions, number of slots, and conductors per slot. Assume it to be wave winding. (7)
- 13 a) List the factors to be considered for the choice of specific electric loading in synchronous machines. (4)
- b) A 3 phase 1800 kVA, 3.3 kV, 50 Hz, 250 rpm, salient pole alternator has the following design data. (i) Stator bore diameter = 230 cm (ii) Gross length of stator bore = 38 cm, (iii) Number of stator slots = 216, (iv) Number of conductors per slot = 4 (v) Sectional area of stator conductor = 86 mm², Using the above data, calculate (i) Flux per pole (ii) Flux density in the air gap (iii) Current density (iv) Size of stator slot. (6)
- 14 a) What are the advantages and disadvantages of higher number of poles in dc machine? (5)
- b) Explain any 3 methods of cooling for turbo alternators. (5)

PART D

Answer any two full questions, each carries 10 marks.

- 15 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, Average gap density=0.4 Wb/m², ampere conductors per metre = 25,000 A/m, Efficiency = 90%, 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 conductors. (10)
- 16 a) Explain on synthesis method of solving electrical machine using CAD with a flow chart. (7)
- b) What are the advantages of hybrid methods? (3)
- 17 a) Explain how finite element method is used for analysis of electrical machines. (5)
- b) Derive from first principles, the output equation of a 3-phase induction motor. Explain each term used. (5)

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh semester B.Tech examinations (S), September 2020

Course Code: EE409**Course Name: Electrical Machine Design**

Max. Marks: 100

Duration: 3 Hours

PART A*Answer all questions, each carries 5 marks.*

Marks

- | | | |
|---|---|-----|
| 1 | Establish a relation between apparent flux density and real flux density for the armature teeth of a DC machine. | (5) |
| 2 | What are the advantages of square core over rectangular core of a transformer? | (5) |
| 3 | Explain why a stationary armature and revolving field type of construction is most convenient for a synchronous generator. | (5) |
| 4 | What are the important points to be considered while selecting the type of winding in dc machine? | (5) |
| 5 | What are the guiding factors that decide the selection of ampere conductors per metre of an induction machine? | (5) |
| 6 | Derive output equation of induction machine. | (5) |
| 7 | What are the salient points of analysis methods of design of machine? Draw the flow chart corresponding to analysis method. | (5) |
| 8 | What are the hybrid techniques available for computer aided design? | (5) |

PART B*Answer any two full questions, each carries 10 marks.*

- | | | |
|----|---|------|
| 9 | a) What do you understand by continuous, short time and short time intermittent ratings of an electrical machine? | (5) |
| | b) What is carter's coefficient and how does it help in estimation of mmf of slotted armature? | (5) |
| 10 | a) What are the practical aspects of unbalanced magnetic pull that must be considered while designing electrical machines? | (5) |
| | b) Derive the output equation of a three-phase transformer. | (5) |
| 11 | Calculate the approximate overall dimensions for a 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 a 3 stepped core. For a 3 stepped core: Width of largest stamping = 0.9d and net iron area = 0.6d ² where d is the diameter of the circumscribing circle. | (10) |

PART C

Answer any two full questions, each carries 10 marks.

- 12 a) What is meant by specific electric and specific magnetic loading in a dc machine? From first principles, obtain the expressions for specific magnetic loading and specific electric loading. (5)
- b) A 350KW, 500V, 450 rpm, 6 pole dc generator is to be built with an armature diameter of 0.87m and core length of 0.32 m. The lap wound armature has 660 conductors. Calculate the specific electric and specific magnetic loadings. (5)
- 13 A 500KW, 460V, 8 pole, 375 rpm compound generator has an armature diameter of 1.1m and core length of 0.33m. Design a symmetrical armature winding. The armature ampere conductors/metre are 34000. The internal voltage drop is 4% of terminal voltage and field current is 1% of output current. The ratio of pole arc to pole pitch is 0.7. The voltage between adjacent segments at no load should not exceed 15V and the slot loading should not exceed 1500 amps. The diameter of the commutator is 0.65 of armature diameter and minimum allowable pitch of segment is 4mm. Make suitable assumptions. (10)
- 14 a) Derive the output equation of a synchronous generator (4)
- b) Find the main dimensions of a 2500 KVA, 187.5 rpm, 50 Hz 3 phase 3 KV salient pole synchronous generator. The generator is to be a vertical water wheel type. The specific magnetic loading is 0.6 Wb/m^2 . The specific electric loading is 34000 Amp/m. Use circular poles with ratio of core length to pole pitch is 0.65. Specify the type of pole construction used. The runaway speed is about 2 times the normal speed. (6)

PART D

Answer any two full questions, each carries 10 marks.

- 15 a) Explain the procedure for design of rotor bars and slots in a squirrel cage induction motor. (5)
- b) Describe the salient features of computer aided design of electrical machines. What are the advantages of computer aided design? (5)
- 16 a) Derive an expression for the end ring current of a squirrel cage induction motor. (5)
- b) Explain how FEM is used for the analysis of electrical machines. (5)
- 17 A 15KW, 440V, 4 poles, 50Hz, 3 Phase induction motor is built with a stator bore 0.25m and core length of 0.16m. The specific loading is 23000Amp conductors/m. Using the data of this machine; determine the core dimensions, no. of stator slots and number of stator conductors for a 11 KW, 460V, 6 pole, 50Hz motor. Assume a full load efficiency of 84% and power factor of 0.82 for each machine. The winding factor is 0.955. (10)

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree Examination (Regular and Supplementary), December 2020

Course Code: EE409**Course Name: Electrical Machine Design**

Max. Marks: 100

Duration: 3 Hours

PART A*Answer all questions, each carries 5 marks.*

Marks

- | | | |
|---|---|-----|
| 1 | What considerations impose limitations in design of electrical machines? | (5) |
| 2 | Distinguish between power transformers and distribution transformers. | (5) |
| 3 | Explain the procedure for designing the shunt field winding for a DC machine. | (5) |
| 4 | What are the factors to be considered for the design of field winding in a synchronous machine? | (5) |
| 5 | What are the guiding factors for the choice of number of armature slots in a three-phase induction machine? | (5) |
| 6 | What are the criteria for the choice of number of slots of an induction machine? | (5) |
| 7 | What are the advantages of FEM based methods over conventional design methods? | (5) |
| 8 | Compare the analysis method and synthesis method of machine design. | (5) |

PART B*Answer any two full questions, each carries 10 marks.*

- | | | |
|----|---|------|
| 9 | The temperature rise of a transformer is 25°C after 1 hour and 37.5°C after 2 hours of starting from cold conditions. Calculate its final steady temperature rise and the heating time constant. If its temperature falls from the final steady state value to 40°C in 1.5 hours when disconnected, calculate the cooling time constant. The ambient temperature is 30°C. | (10) |
| 10 | a) What are the practical aspects of unbalanced magnetic pull that must be considered while designing electrical machines? | (5) |
| | b) A 200 KVA, 6600/440 V 50Hz, 3 phase core type transformer has the following design data. Maximum flux density = 1.3 wb/m ² , emf per turn = 10V, stacking factor = 0.9, window space factor = 0.3, current density = 2.5 A/mm ² , overall width = overall height, 3 stepped core is used. Calculate the overall dimensions of the transformer. | (5) |
| 11 | A 250KVA, 6600/400 V, 3 phase core type transformer has a total loss of 4800 W at full load. The transformer tank is 1.25 m in height and 1m×0.5m in plan. Design a suitable scheme for the tubes if the average temperature rise is to be limited to 35°C. The diameter of the tube is 50mm and is spaced 75mm from each other. The average height of the tube is 1.05m. Specific heat dissipation due | (10) |

to radiation and convection is respectively 6 and 6.5 W/m²°C. Assume that the convection is improved by 35% due to provision of tubes.

PART C

Answer any two full questions, each carries 10 marks.

- 12 a) Explain the criterion for the selection of number of poles in a dc machine. (5)
- b) What are the design procedure of the field winding of a dc machine? (5)
- 13 A shunt field coil has to develop an mmf of 8000A. The voltage drop in the coil is 40 V and the resistivity of the round wire used is 0.021 Ω/m and mm². The depth of the winding is 35 mm approximately and the length of the mean turn is 1.8 m. Design a coil so that the power dissipated is 800 W/m² of the total coil surface. Take the diameter of the insulated wire 0.2 mm greater than that of bare wire. (10)
- 14 a) Derive the output equation of a synchronous machine. (4)
- b) Estimate the diameter, core length, size, number of conductors and number of slots for stator of a 15MVA, 11KV, 50Hz, 2 pole star connected turboalternator with 60° phase spread. Assume $B_{av}=0.55\text{Wb/m}^2$, $a_c=36000\text{Amp/m}$, current density= 5A/mm^2 , peripheral speed= 160m/sec . The winding should be arranged to eliminate 5th harmonics. (6)

PART D

Answer any two full questions, each carries 10 marks.

- 15 a) What are the factors to be considered for the selection of air gap length of an induction motor? (5)
- b) Derive an expression for the end ring current of a squirrel cage induction motor. (5)
- 16 a) Describe about finite element methods. What are its advantages and applications? (6)
- b) What is computer aided design? How does it help in designing electrical machines? (4)
- 17 Estimate the stator core dimensions, number of stator slots and number of stator conductors per slot for a 100KW, 3300V, 50Hz, 12 pole star connected slip ring induction motor. Assume average gap density 0.4Wb/m², ampere conductors/m= 25000A/m , efficiency=0.9, Power factor=0.96. Choose main dimensions to give best power factor. The slot loading should not exceed 500 Ampere conductors. (10)
