SRM VALLIAMMAI ENGINEERING COLLEGE

(Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

VI SEMESTER

1905603-DESIGN OF ELECTRICAL APPARATUS

Regulation – 2019

Academic Year 2024-2025 Even

Prepared by

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SUBJECT & SUBJECT CODE: 1905603-DESIGN OF ELECTRICAL APPARATUS

SEM / YEAR: VI / III

UNIT-I DESIGN OF FIELD SYSTEM AND ARMATURE				
Major considerations in Electrical Machine Design – Materials for Electrical apparatus Space factor –Choice of Specific Electrical and Magnetic loadings - Design of Magnetic circuits – Magnetising current – Flux leakage – Leakage in Armature. Design of lap winding and wave winding.				
PART-A				
Q. No	**Questions**	**BT Level**	**Competence**	**CO**
1.	What are the factors that affect the size of rotating machines?	BTL1	Remembering	CO1
2.	Explain specific electric loading.	BTL2	Understanding	CO1
3.	List the basic components of electromagnetic apparatus.	BTL1	Remembering	CO1
4.	Describe the limitations in design.	BTL2	Understanding	CO1
5.	Sketch the properties of magnetic materials.	BTL3	Applying	CO1
6.	Execute the types of magnetic materials.	BTL3	Applying	CO1
7.	Define the properties of conducting material.	BTL1	Remembering	CO1
8.	Judge and compare the properties of copper and aluminum.	BTL5	Evaluating	CO1
9.	Extract about space factor.	BTL2	Understanding	CO1
10.	Illustrate total magnetic loading.	BTL4	Analyzing	CO1
11.	Identify the components of electromagnetic apparatus.	BTL1	Remembering	CO1
12.	Organize the properties of magnetic materials.	BTL4	Analyzing	CO1
13.	Infer about total electric loading.	BTL2	Understanding	CO1
14.	Compare properties of copper and aluminum.	BTL4	Analyzing	CO1
15.	Demonstrate about liquid insulating material.	BTL3	Applying	CO1
16.	State the components of electromagnetic apparatus.	BTL1	Remembering	CO1
17.	Define space factor.	BTL1	Remembering	CO1
18.	Construct the types of ferro magnetic material.	BTL6	Creating	CO1
19.	Compose about specific magnetic loading.	BTL6	Creating	CO1

20.	Appraise the properties of insulating material.		BTL5	Evaluating	CO1
21.	Recall the classification of insulating material.		BTL1	Remembering	CO1
22.	Discuss about solid insulating material.		BTL2	Understanding	CO1
23.	Articulate about specific electric loading.		BTL3	Applying	CO1
24.	Analyze lap and wave winding.		BTL4	Analyzing	CO1
	PART-B				
1.	Explain in detail about major considerations in electrical machine design.	(13)	BTL1	Remembering	CO1
2.	Describe about electrical engineering materials.	(13)	BTL2	Understanding	CO1
3.	Discover in detail about specific magnetic loading and electric loading.	(13)	BTL3	Applying	CO1
4.	List out the Difference between Lap Winding and Wave Winding.	(13)	BTL2	Understanding	CO1
5.	What are the main groups of electrical conducting materials? Explain the properties and applications of those materials.	(13)	BTL1	Remembering	CO1
6.	A 350 kW, 500 V,450 rpm, 6 pole DC generator is 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 magnetic loading.	(13)	BTL3	Applying	CO1
7.	Analyze the advantages of wave winding over lap winding.	(13)	BTL4	Analyzing	CO1
8.	Define Lap Winding and Wave Winding and also state the difference.	(13)	BTL1	Remembering	CO1
9.	Summarize how to design simplex lap-winding.	(13)	BTL2	Understanding	CO1
10.	Explain leakage flux and leakage in armature.	(13)	BTL1	Remembering	CO1
11.	A 20 HP, 440 V, 4 poles, 50 Hz, 3 phase induction motor is built with a stator bore of 0.25m and core length of 0.16m. The specific electric loading is 23000 ampere conductors per meter. Calculate the specific magnetic loading of the machine. Assume full load efficiency of 84% and a power factor of 0.82.	(13)	BTL4	Analyzing	CO1
12.	Interpret in detail about electrical engineering materials.	(13)	BTL3	Applying	CO1
13.	Compose a developed diagram of a simple 2-layer lap-winding for a 4-pole generator with 16 coils.	(13)	BTL5	Evaluating	CO1

14.	Pivot the details of choice of specific magnetic and electric loading.	(13)	BTL6	Creating	CO1
15.	Quote the details about simplex lap-winding.	(13)	BTL1	Remembering	CO1
16.	A 250 kW, 450 V, 350 rpm, 6 pole DC generator is built with an armature diameter of 0.8m and core length of 0.3m, the lap wound armature has 660 conductors. Calculate the specific electric and magnetic loading.	(13)	BTL2	Understanding	CO1
17.	Draw a developed diagram of a simple 2-layer lap-winding for a 4-pole generator with 16 coils.	(13)	BTL3	Applying	CO1
	PART-C				
1.	Calculate the specific electric and magnetic loading for a 300 kW, 500 V, 450 rpm, 6 pole DC generator is built with an armature diameter of 0.87m and core length of 0.32 m, the lap wound armature has 660 conductors.	(15)	BTL5	Evaluating	CO1
2.	Evaluate the key Differences between Lap Winding and Wave Winding	(15)	BTL5	Evaluating	CO1
3.	Generalize the major considerations to evolve a good design of electrical machine.	(15)	BTL6	Creating	CO1
4.	State and explain the main factors which influence the choice of specific magnetic loading and specific electric loading in the design of rotating machines.	(15)	BTL6	Creating	CO1
5.	Draw a developed diagram of a simplex 2-layer wave-winding for a 4-pole dc generator with 30 armature conductors. Hence, point out the characteristics of a simple wave winding.	(15)	BTL4	Analyzing	CO1

UNIT-II DESIGN OF TRANSFORMERS

Construction - KVA output for single and three phase transformers – Overall dimensions – design of yoke, core and winding for core and shell type transformers – Estimation of No load current – Temperature rise in Transformers – Design of Tank and cooling tubes of Transformers. Computer program: Complete Design of single phase core transformer.

PART-A

Q. No	**Questions**	**BT Level**	**Competence**	**CO**
1.	What are the advantages of stepped core in transformer and why it is generally used?	BTL1	Remembering	CO2
2.	List the different losses in a transformer.	BTL2	Understanding	CO2

3.	What is window space factor?		BTL1	Remembering	CO2
4.	Explain how the heat dissipates in a transformer.		BTL2	Understanding	CO2
5.	Why the area of yoke of a transformer is usually kept 15-20% more than that of core?		BTL3	Applying	CO2
6.	Discuss iron space factor.		BTL3	Applying	CO2
7.	What is conservator?		BTL1	Remembering	CO2
8.	Explain why circular coils are preferred in transformers.		BTL5	Evaluating	CO2
9.	Why the efficiency of transformer is so high?		BTL2	Understanding	CO2
10.	Distinguish between shell type and core type transformer.		BTL4	Analyzing	CO2
11.	Give the relationship between emf per turn and KVA rating in a transformer.		BTL1	Remembering	CO2
12.	Prepare the list of factors affecting the choice of flux density of core in a transformer.		BTL4	Analyzing	CO2
13.	The voltage per turn of a 500KVA, 11KV, Δ/Y three phase transformer is 8.7V.Calculate the number of turns per phase of LV and HV windings.		BTL2	Understanding	CO2
14.	How is iron loss reduced in transformers?		BTL4	Analyzing	CO2
15.	What is the range of efficiency of a transformer?		BTL3	Applying	CO2
16.	Prepare the list if factors to be considered for selecting the cooling methods of a transformer.		BTL1	Remembering	CO2
17.	Explain the main function of cooling medium used in transformers.		BTL1	Remembering	CO2
18.	Define stacking factor.		BTL6	Creating	CO2
19.	Discuss about leg spacing.		BTL6	Creating	CO2
20.	Explain why stepped core are generally used for transformer.		BTL5	Evaluating	CO2
21.	List the classifications of transformer based on application.		BTL1	Remembering	CO2
22.	Compare core type and shell type transformer		BTL2	Understanding	CO2
23.	Prepare the classification of transformer based on construction.		BTL3	Applying	CO2
24.	Deduce the schematic view of core type transformer.		BTL4	Analyzing	CO2
PART-B					
1.	Estimate the main dimensions including winding conductor area of a 3-phase delta-star core type transformer rated at 300 kVA, 6600/440V, 50 Hz. A suitable core with 3-steps having a circumscribing circle of 0.25m diameter and leg	(13)	BTL1	Remembering	CO2

	spacing of 0.4m is available. Emf per turn 8.5 V, current density=2.5A/mm sq, Kw=0.28, stacking factor S_f=0.9.				
2.	The tank of 1250kVA natural oil cooled transformer has the dimensions length, width and height as 0.65*1.55*1.85 m respectively. The load loss=13.1kW, loss dissipation due to radiations 6W/m.sq-0 C, improvement in convection due to provision of tubes=40%, temperature rise is 40^{o}C, length of each tube is 1m, diameter of each tube is 50mm. Find the number of tubes for this transformer. Neglect the top and bottom surface of the tank as regards the cooling.	(13)	BTL2	Understanding	CO2
3.	(i)What are the salient features of distribution transformer? (ii) State and explain the different methods of cooling the transformer.	(8) (7)	BTL3	Applying	CO2
4.	A 250kVA, 6600/400V, 3-phase core type transformer has a total loss of 4800V on full load. The transformer tank is 1.25m in height and 1m*0.5m in plan. Design a suitable scheme for cooling tubes if the average temperature rise is to be limited to 35^{o}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 is 6 and 6.5 W/m^2/^{o}C. Assume convection is improved by 35% due to provision of tubes.	(13)	BTL2	Understanding	CO2
5.	Describe the methods of cooling of transformers.	(13)	BTL1	Remembering	CO2
6.	A single-phase 400V, 50Hz transformer is built from stampings having a relative permeability of 1000. The length of the flux path is 2.5*10-3 m2 and the primary winding has 800 turns. Estimate the maximum flux and no load current of the transformer. The iron loss at the working flux density is 2.6 W/Kg. Iron weighs 7.8*1000 Kg/m3. Stacking factor is 0.9	(13)	BTL3	Applying	CO2
7.	Derive the output equation of single-phase and	(13)	BTL4	Analyzing	CO2

	three phase transformer.				
8.	Explain the step by step procedure for the design of core, shell type transformer, windings and yoke.	(13)	BTL1	Remembering	CO2
9.	Identify the full load MMF for the ratio of flux in weber to full load mmf in a 400 kVA,50 Hz, single-phase, core type transformer is $2.4*10^{-6}$. Also identify calculate the net iron area and window area of the transformer. Assume maximum flux density in the core is 1.3 Wb/m^2 & current density is 2.7 A/mm^2 and window area constant 0.26.	(13)	BTL2	Understanding	CO2
10.	Identify overall dimensions for a three phase,250 kVA,6600/440 V, 50 Hz core type transformer with the following data. Emf/turn =11.5 V, maximum flux density =1.75 wb/m^2 current density =2.5 A/mm^2 window space factor = 0.32 stacking factor = 0.94 overall height= overall width, a 3 stepped core is used, width of the largest stamping = 0.9d and the net iron area = 0.6 d^2 where d is the diameter of circumscribing circle.	(13)	BTL1	Remembering	CO2
11.	Calculate the core and window areas required for a 100 kVA 6600/400V 50 Hz single phase core type transformer. Assume a maximum flux density 1.25 wb/m^2 and a current density of 2.5 A/mm^2 voltages per turn is 30, window space factor is 0.32.	(13)	BTL4	Analyzing	CO2
12.	Calculate the main dimensions and winding details of a 100 kVA 2000/400 V 50 Hz single phase shell type, oil immersed, self cooled transformer. Assume voltage per turn 10 V, flux density in core 1.1 wb/m^2, current density 2 A/mm^2, window space factor 0.33. The ratio of window height to window width and ratio of core depth to width of central limb = 2.5, the stacking factor is 0.9.	(13)	BTL3	Applying	CO2
13.	Identify the full load MMF for the ratio of flux in weber to full load mmf in a 350 kVA,50 Hz,	(13)	BTL5	Evaluating	CO2

	single-phase, core type transformer is $2.4*10^{-6}$. Also identify calculate the net iron area and window area of the transformer. Assume maximum flux density in the core is 1.2 Wb/m^2 & current density is 2.7 A/mm^2 and window area constant 0.26.				
14.	Identify overall dimensions for a three phase, 300 kVA,6600/440 V, 50 Hz core type transformer with the following data. Emf/turn =10.5 V, maximum flux density =1.75 wb/m^2 current density =2.5 A/mm^2 window space factor = 0.32 stacking factor = 0.94 overall height= overall width, a 3 stepped core is used, width of the largest stamping = 0.9d and the net iron area = 0.6 d^2 where d is the diameter of circumscribing circle.	(13)	BTL6	Creating	CO2
15.	Calculate the core and window areas required for a 150 kVA 6600/400V 50 Hz single phase core type transformer. Assume a maximum flux density 1.25 wb/m^2 and a current density of 2.5 A/mm^2 voltages per turn is 30, window space factor is 0.32.	(13)	BTL1	Remembering	CO2
16.	A single-phase 350V, 50Hz transformer is built from stampings having a relative permeability of 1000. The length of the flux path is 2.5*10-3 m2 and the primary winding has 800 turns. Estimate the maximum flux and no load current of the transformer. The iron loss at the working flux density is 2.6 W/Kg. Iron weighs 7.8*1000 Kg/m3. Stacking factor is 0.9	(13)	BTL2	Understanding	CO2
17.	A 200kVA, 6600/400V, 3-phase core type transformer has a total loss of 4800V on full load. The transformer tank is 1.25m in height and 1m*0.5m in plan. Design a suitable scheme for cooling tubes if the average temperature rise is to be limited to 35^oC. 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 is 6 and 6.5 $W/m^2/^oC$. Assume convection is improved by 35% due to provision	(13)	BTL3	Applying	CO2

	of tubes.				
PART-C					
1.	The tank of 1200kVA natural oil cooled transformer has the dimensions length, width and height as 0.65*1.55*1.85 m respectively. The load loss=13.1kW, loss dissipation due to radiations 6W/m.sq-0 C, improvement in convection due to provision of tubes=40%, temperature rise is 40^{o}C, length of each tube is 1m, diameter of each tube is 50mm. Find the number of tubes for this transformer. Neglect the top and bottom surface of the tank as regards the cooling.	(15)	BTL5	Evaluating	CO2
2.	Estimate the main dimensions including winding conductor area of a three-phase delta-star core type transformer rated at 300 kVA,6600/440V 50 Hz. A suitable core with 3 steps having a circumscribing circle of 0.25 m diameter and leg spacing of 0.4m is available. Emf/turn=8.5 V, $^{\delta}$=2.5 A/mm^{2,} Kw= 0.28,Ki=0.9.	(15)	BTL5	Evaluating	CO2
3.	A 3 phase, 50Hz, oil cooled core type transformer has the following dimensions: Distance between core centers=0.2m , height of window =0.24m, Diameter circumscribing Circle =0.14m. The flux density in the core =1.25Wb/m^2, the current density in the conductor =2.5 A/mm^2. Assume a window space factor of 0.2 and the core area factor =0.56. The core is two stepped. Estimate KVA rating of the transformer.	(15)	BTL6	Creating	CO2
4.	A 1000kVA, 6600/440V,50Hz, 3 phase delta/star, core type oil immersed natural cooled transformer. The design data of the transformer is: distance between adjacent links=0.47m, outer diameter of HV winding=0.44m, height of frame=1.24m, core loss=3.7kW and I^{2}R loss= 10.5kW. Design a suitable tank for the transformer. The average temperature rise of oil should not exceed 35^{0}C. The specific heat dissipation from the tank walls is 6W/m^2-^{o}C and	(15)	BTL6	Creating	CO2

	6.5W/m^2-^{o}C due to radiation and convection respectively. Assume that the convection is improved by 35% due to provision of tubes.				
5.	Determine the main dimensions of the core of a 5kVA, 11000/400V, 50Hz, 1 phase core type distribution transformer. The net conductor area in the window is 0.6 times the net cross section area of iron in the core. The core is of square cross section, maximum flux density is 1Wb/m^2. Current density is 1.4A/mm^2. Window space factor is 0.2. Height of the window is 3 times its width.	(15)	BTL4	Analyzing	CO2

UNIT-III DESIGN OF DC MACHINES

Construction - Output Equations – Main Dimensions – Choice of specific loadings –Carter's Coefficient - Net length of Iron –Real & Apparent flux densities - Selection of number of poles – Design of Armature – Design of commutator and brushes – design of field - Computer program: Design of Armature main dimensions.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Write the expression for output equation of a dc machines.	BTL1	Remembering	CO3
2.	Explain carter's gap coefficient.	BTL2	Understanding	CO3
3.	Compare electric and magnetic circuit.	BTL1	Remembering	CO3
4.	What are the constituents of magnetic circuits in a dc machine?	BTL2	Understanding	CO3
5.	What is real and apparent flux density?	BTL3	Applying	CO3
6.	List the methods for calculating mmf for teeth.	BTL3	Applying	CO3
7.	Define copper space factor of a coil.	BTL1	Remembering	CO3
8.	Define leakage flux and fringing flux.	BTL5	Evaluating	CO3
9.	Explain why square pole face is preferred.	BTL2	Understanding	CO3
10.	Give the main parts of dc machine.	BTL4	Analyzing	CO3
11.	Explain total gap contraction factor.	BTL1	Remembering	CO3
12.	Explain window space factor.	BTL4	Analyzing	CO3
13.	Define stacking factor.	BTL2	Understanding	CO3
14.	How will you calculate the net length of iron?	BTL4	Analyzing	CO3
15.	What factor decides the minimum number of armature coils?	BTL3	Applying	CO3
16.	Define field form factor.	BTL1	Remembering	CO3

17.	Mention the two types of armature winding used in dc machine and compare.		BTL1	Remembering	CO3
18.	Mention guiding factors for the selection of number of poles.		BTL6	Creating	CO3
19.	List the factors that influence choices of commutator diameter.		BTL6	Creating	CO3
20.	State the relationship between the number of commutator segments and number of armature coils in dc generator.		BTL5	Evaluating	CO3
21.	Define electric circuit.		BTL1	Remembering	CO3
22.	Mention the effects of high specific electric loading.		BTL2	Understanding	CO3
23.	Articulate field form factor.		BTL3	Applying	CO3
24.	Analyze total gap contraction factor.		BTL4	Analyzing	CO3
PART-B					
1.	Find the main dimensions and the no. of poles of a 37kW, 230V, 1400 rpm shunt motor, so that a square pole face is obtained. The average gap density is 0.5 Wb/m^2 and the ampere conductors per meter are 22,000. The ratio of pole arc to pole pitch is 0.7 and the full load efficiency is 90%	(13)	BTL1	Remembering	CO3
2.	(i) Draw the magnetic circuit of dc machine. (ii) State and explain the factors which govern the choice of specific magnetic loading in a dc machine.	(13)	BTL2	Understanding	CO3
3.	Estimate the main dimensions of a 200 kW, 250 volts, 6 pole, 1000, rpm DC generator. The maximum value of flux density in the air gap is 0.87 wb/m2 and the ampere conductors per metre length of armature periphery are 31000; The ratio of pole arc to pole pitch is 0.67 and the efficiency is 91 percent. Assume that the ratio of length of core to pole pitch = 0.75.	(13)	BTL3	Applying	CO3
4.	For a preliminary design of a 50HP, 230V, 1400 rpm, dc shunt motor. Calculate the armature diameter and core length, the no. of poles and peripheral speed. Take Bav=0.5 wb/sq.m,. ac/m=25,000, efficiency=0.9.	(13)	BTL2	Understanding	CO3
5.	Derive the relation between real and apparent flux densities in dc machine.	(13)	BTL1	Remembering	CO3

6.	Design the diameter and length of armature core for a 55 kW, 110 V,1000 rpm, 4 pole shunt generator, assuming specific electric and magnetic loadings of 26000 amp. cond./m and 0.5Wb/m^2 respectively. The pole arc should be about 70% of pole pitch and length of core about 1.1 times the pole arc. Allow 10 ampere for the field current and assume a voltage of 4V for the armature circuit. Specify the winding used and also determine suitable values for the number of armature conductors and number of slots.	(13)	BTL3	Applying	CO3
7.	(i) Derive the output equation of dc machine (ii) Derive an expression for the mmf for airgap of a slotted armature with ducts.	(8) (7)	BTL4	Analyzing	CO3
8.	Identify the main dimensions, number of poles and the length of air-gap of a 1000 kW, 500V, 300rpm dc generator. Assume average gap density as 0.7 Wb/m^2 and ampere conductors per meter as 40000. The pole arc to pole pitch ratio is 0.7 and the efficiency is 92%. The mmf required for air gap is 55% of armature mmf and gap contraction factor is 1.15. The following are the design constraints: peripheral speed should not exceed 30m/s, frequency of flux reversals should not exceed 50Hz, current per brush arm should not exceed 400 A, and armature mmf per pole should not exceed 10000 AT	(13)	BTL1	Remembering	CO3
9.	Deign a suitable commutator for a 350KW,600 rpm,440V, 6 pole dc generator having an armature diameter of 0.75m. The number of coils is 288. Assume suitable values wherever necessary.	(13)	BTL2	Understanding	CO3
10.	Identify the diameter and length of armature for a 7.5kW, 4 pole, 1000rpm, 220V shunt motor. Given: full load efficiency=0.83; Maximum gap flux density=0.9 Wb/$m^{2;}$ specific electric loading=30000 ampere conductors per meter; field form facto=0.7. Assume that the maximum efficiency occurs at full load and the field current	(13)	BTL1	Remembering	CO3

	is 2.5% of rated current. The pole face is square.				
11.	A 5 KW, 250 volts and 4 pole, 1500 rpm d.c. shunt generator is designed to have a square pole face. The average magnetic flux density in the air gap is 0.42 wb/m2 and ampere conductors per metre = 15000. Compute the main dimensions of the machine. Assume full load efficiency = 87%. The ratio of pole arc to pole pitch = 0.66.	(13)	BTL4	Analyzing	CO3
12.	Explain the procedure for the selection of number of poles in the machine**.** What are the advantages and disadvantages of large number of poles in a dc machine?	(13)	BTL3	Applying	CO3
13.	Design the suitable dimensions of armature core of a d.c. generator which is rated 50 kW. P = 4, N = 600 rpm. Full load terminal voltage is 220 volts. Maximum gap flux density is 0.83 Wb/ m^2 and specific electric loading is 30,000. Ampere conductors/metre. Full load armature voltage drop is 3 percent of rated terminal voltage. Field current is 1 percent of full load current Ratio of pole arc to pole pitch is 0.67 pole face is a square.	(13)	BTL5	Evaluating	CO3
14.	A 4 pole 50 HP de shunt motor operates with rated voltages of 480 volts at rated speed of rpm. It has wave wound armature with 770 conductors. The leakage factor of the poles is 1.2. The poles are of circular cross section. The flux density in the poles is 1.5 Wb/ m2. Compute diameter of each pole.	(13)	BTL6	Creating	CO3
15.	Identify the main dimensions of the machine for a 500 kW,250V, 4 pole, 1500 rpm shunt generator is designed to have a square pole face. The loadings are: average flux density in the gap=0.42Wb/m^2 and ampere conductors per meter=15000. Assume full load efficiency 0.87 and ratio of pole arc to pole pitch=0.66.	(13)	BTL1	Remembering	CO3
16.	Explain the various steps involved in design of shunt field winding of DC Machine.	(13)	BTL2	Understanding	CO3
17.	For a preliminary design of a 40HP, 230V, 1400 rpm, dc shunt motor. Calculate the armature	(13)	BTL3	Applying	CO3

	diameter and core length, the no. of poles and peripheral speed. Take Bav=0.5 wb/sq.m,. ac/m=25,000, efficiency=0.9.				
	PART-C				
1.	Determine the air gap length of the DC machine from the following particulars: gross length of the core =0.12, number of Ducts = one and 10mm wide, slot pitch=25mm, slot width =10mm, carter's coefficient for slots and ducts =0.32, gap density at pole center =0.7Wb/m^2; field mmf/pole =3900AT, mmf required for iron parts of magnetic circuit =800AT.	(15)	BTL5	Evaluating	CO3
2.	A 15 kW,230 V,4 pole dc machine has armature diameter=0.25m, armature core length=0.125m, length of airgap at pole centre=2.5mm, flux/pole=11.7x10^{-3}Wb, ratio of pole arc/pole pitch=0.66. Calculate the mmf required for airgap (i)if the armature surface is treated as smooth (ii) if the armature is slotted and the gap contraction factor is 1.18.	(15)	BTL5	Evaluating	CO3
3.	Calculate the mmf required for the airgap of a machine having core length=0.32m, including 4 ducts of 10mm each, pole arc=0.19m, slot pitch=65.4mm,slot opening=5mm, airgap length=5mm, flux/pole=52mWb, given carter's coefficient is 0.18 for opening/gap=1 and is 0.28 for opening/gap=2	(15)	BTL6	Creating	CO3
4.	Estimate the effective gap area per pole of a 10 pole, slip ring induction motor with following data: stator bore=0.65m, core length =0.25m, number of stator slots=90, stator slot opening=3mm, rotor slots=120, rotor slot opening=3 mm, airgap length=0.95mm, carter's coefficient for ducts=0.68, carter's coefficient for slots=0.46, number of ventilating ducts=3 each on rotor and stator, width of each ventilating duct=10mm.	(15)	BTL6	Creating	CO3
5.	Determine the main dimensions, number of poles and length of airgap of a 600kW,500V,900 rpm	(15)	BTL4	Analyzing	CO3

	generator. Assume average gap density as $0.6 Wb/m^2$ and ampere conductors/m as 35000. The ratio of pole arc/pole pitch is 0.75 and the efficiency is 91%. The following are the design constraints: Peripheral speed ≯ 40 m/s, frequency of flux reversals ≯ 50Hz, current/brush arm ≯400A and armature mmf/pole ≯7500A. The mmf required for airgap is 50% of armature mmf and gap contraction factor is 1.15.				

UNIT-IV DESIGN OF INDUCTION MOTORS

Construction - Output equation of Induction motor – Main dimensions – choice of specific loadings – Length of air gap - Design of squirrel cage rotor and wound rotor –Magnetic leakage calculations – Operating characteristics : Magnetizing current - Short circuit current – Circle diagram - Computer program: Design of slip-ring rotor.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	List the advantages of using open slots.	BTL1	Remembering	CO4
2.	Why induction motor is called as rotating transformer?	BTL2	Understanding	CO4
3.	What are the factors to be considered for the choice of specific electric loading?	BTL1	Remembering	CO4
4.	How the induction motor can be designed for best power factor?	BTL2	Understanding	CO4
5.	Discuss the reason for the unbalanced magnetic pull in an induction motor.	BTL3	Applying	CO4
6.	Articulate the merits of using open slots.	BTL3	Applying	CO4
7.	How the dimensions of induction generator differ from that of an induction motor?	BTL1	Remembering	CO4
8.	State the use of slip ring rotor.	BTL5	Evaluating	CO4
9.	Define runaway speed.	BTL2	Understanding	CO4
10.	Why is the length of air gap in an induction motor kept at minimum possible range?	BTL4	Analyzing	CO4
11.	Explain the effects of change of air gap length in an induction motor?	BTL1	Remembering	CO4
12.	Define dispersion coefficient and give its significance in an induction motor.	BTL4	Analyzing	CO4
13.	What are the factors to be considered for estimating the length of air-gap in induction motor?	BTL2	Understanding	CO4

14.	Differentiate crawling and cogging. How cogging is avoided in IM?		BTL4	Analyzing	CO4
15.	Why fractional slot winding is not used for induction motor?		BTL3	Applying	CO4
16.	Define integral slot winding and fractional slot winding.		BTL1	Remembering	CO4
17.	Name the losses that occur in three phase IM.		BTL1	Remembering	CO4
18.	Estimate the ranges of efficiency and power factor in induction motor.		BTL6	Creating	CO4
19.	Describe full pitch and short pitch or chording.		BTL6	Creating	CO4
20.	Name the methods used for reducing harmonic torques in induction motor.		BTL5	Evaluating	CO4
21.	List out the losses in Induction Motor.		BTL1	Remembering	CO4
22.	Define crawling.		BTL2	Understanding	CO4
23.	Interpret cogging.		BTL3	Applying	CO4
24.	Analyze the ranges of efficiency and power factor in induction motor.		BTL4	Analyzing	CO4
	PART-B				
1.	Determine the main dimensions, number of radial ventilating ducts, number of stator slots and number of turns/ phase of a 3.7kW,400 V, 3 phase, 4 pole, 50Hz, squi.cage IM. to be started by a star delta starter. Workout the winding details assume Average flux density=0.45Wb/m^2 ac=23000 amp.cond/m, full load efficiency=0.85, pf=0.84. choose main dimensions to achieve cheap design. winding factor=0.955, stacking factor=0.9.	(13)	BTL1	Remembering	CO4
2.	Calculate the magnetising current of a 450V, 4 pole, 3-phase, 50Hz, induction motor having the following data. No. of slots=36, No. of stator conductors/ slot=30, stator core diameter=13com, axial length of stator=13cm, effective airgap length=0.1cm, winding is full pitched, phase spread angle is 60^o, gap contraction factor=1, assume that the iron loss has infinite permeability.	(13)	BTL2	Understanding	CO4
3.	Determine the approximate diameter and length of stator core, the no. of stator slots and the no. of stator conductors for a 11kW, 400V, 3-phase, 4	(13)	BTL3	Applying	CO4

	pole, 1425rpm, delta connected IM. Bav=0.45wb/sq.m, ac=23000 amp.cond/m, full load efficiency=0.85, pf=0.88, pole arc to pole pitch is 1. The stator employs a double layer winding.				
4.	Design a cage rotor for a 40HP, 3-phase, 400V, 50Hz, 6 pole delta connected IM having a full load efficiency of 87% and a full load pf of 0.85. Take D=33cm and L=17cm. stator slots=54, conductors/slot=14. Assume suitably the missing data of any.	(13)	BTL2	Understanding	CO4
5.	Identify the main dimension, air gap length, stator slots, slots/ phase and cross sectional area of stator and rotor conductors for three phase, 15HP, 400V, 6 pole, 50Hz, 975 rpm induction motor. The motor is suitable for star – delta starting. Bav = 0.45 wb/m2. ac = 20000 AC/m.L / τ = 0.85. η = 0.9 , P.F = 0.85.	(13)	BTL1	Remembering	CO4
6.	A 15 kW, three phase, 6 pole, 50 Hz, squirrel cage induction motor has the following data, stator bore dia = 0.32m, axial length of stator core = 0.125 m, number of stator slots = 54, number of conductor / stator slot = 24, current in each stator conductor =17.5 A, full load P.F = 0.85 lag. Evaluate number of rotor slots section of each bar and section of each ring for a suitable cage rotor. The full speed is to be 950 rpm, use copper for rotor bar and end ring conductor. Resistivity of copper is 0.02 Ωm.	(13)	BTL3	Applying	CO4
7.	A 90 kW, 500V, 50 Hz, three phase, 8 pole induction motor has a star connected stator winding accommodated is 63 slots with a 6 conductors / slot. If slip ring voltage, an open circuit is to be about 400V at no load find suitable rotor winding. Identify number of rotor slots, number conductors / slot, coil span, number of slots per pole. P.F = 0.9 and the efficiency is 0.85.	(13)	BTL4	Analyzing	CO4
8.	Identify the approximate diameter and length of	(13)	BTL1	Remembering	CO4

	stator core, the number of stator slots and the number of conductors for a 20 kW, 400V, 3 phase, 4pole, 1200rpm, delta connected induction motor. Bav =0.5T, η = 0.82, ac = 26,000 amp.cond /m, power factor = 0.8, L/τ = 1, double layer stator winding.				
9.	Estimate the main dimensions, air-gap length, stator slots, stator turns per phase and cross sectional area of stator and rotor conductors for 3 phase, 110 kW, 3300V, 50 Hz, 10 poles, 600 rpm, Y connected induction motor, Bav = 0.48 Wb/m2, ac = 28,000 amp.cond/m, L/τ = 1.25, η = 0.9, power factor = 0.86.	(13)	BTL2	Understanding	CO4
10.	Design a cage rotor for a 18.8HP, 3phase, 440V, 50Hz, 1000rpm, induction motor having full load efficiency of 0.86, power factor = 0.86, D=0.25m, L=0.14m, Zss/Ss= 54. Assume missing data if any.	(13)	BTL1	Remembering	CO4
11.	Discuss the advantages and disadvantages of having small airgap of a 3 phase IM.	(13)	BTL4	Analyzing	CO4
12.	Derive the expression for output equation of induction motor.	(13)	BTL3	Applying	CO4
13.	Determine D and L of a 70HP, 415 V, three phase, 50Hz, star connected, 6 pole IM for which ac=30000 A.con/m and B_{av}= 0.51 Wb/m^2. Take efficiency=90% and PF=0.91. Assume τ=L. Estimate the number of stator conductors required for a winding in which the conductors are connected in two parallel paths. Choose a suitable number of conductors per slots so that the slot loading does not exceed 750Amp.cond.	(13)	BTL5	Evaluating	CO4
14.	Find the main dimensions of a 15kW, 3phase,400V, 50Hz, 2810rpm, sq. Cage induction motor having an efficiency of 88% and full load PF=0.9. Assume specific magnetic loading=0.5T, specific electrical loading=25000A/m. The rotor peripheral speed should be approximately 20m/s at synchronous speed.	(13)	BTL6	Creating	CO4

15.	What are the advantages of squirrel cage IM and slip ring IM?	(13)	BTL1	Remembering	CO4
16.	Find the values of diameter and length of stator core of a. 7.5 kW. 220 V, 50 Hz. 4 pole.3 phase induction motor for best power factor.	(13)	BTL2	Understanding	CO4
17.	Estimate the main dimensions, air-gap length, stator slots, stator turns per phase and cross sectional area of stator and rotor conductors for 3 phase, 115 kW, 3300V, 50 Hz, 10 poles, 600 rpm, Y connected induction motor, Bav = 0.48 Wb/m2, ac = 28,000 amp.cond/m, L/τ = 1.25, η = 0.9, power factor = 0.86.	(13)	BTL3	Applying	CO4
PART-C					
1.	Determine the approximate diameter and length of stator core, the no. of stator slots and the no. of stator conductors for a 10kW, 400V, 3-phase, 4 pole, 1425rpm, delta connected IM. Bav=0.45wb/sq.m, ac=23000 amp.cond/m, full load efficiency=0.85, pf=0.88, pole arc to pole pitch is 1. The stator employs a double layer winding.	(15)	BTL5	Evaluating	CO4
2.	Identify the approximate diameter and length of stator core, the number of stator slots and the number of conductors for a 25 kW, 400V, 3 phase, 4pole, 1200rpm, delta connected induction motor. Bav =0.5T, η = 0.82, ac = 26,000 amp.cond /m, power factor = 0.8, L/τ = 1, double layer stator winding.	(15)	BTL5	Evaluating	CO4
3.	Identify the main dimension, air gap length, stator slots, slots/ phase and cross sectional area of stator and rotor conductors for three phase, 20HP, 400V, 6 pole, 50Hz, 975 rpm induction motor. The motor is suitable for star – delta starting. Bav = 0.45 wb/m2. ac = 20000 AC/m.L / τ = 0.85. η = 0.9 , P.F = 0.85.	(15)	BTL6	Creating	CO4
4.	Estimate the main dimensions, air-gap length, stator slots, stator turns per phase and cross sectional area of stator and rotor conductors for 3 phase, 115 kW, 3300V, 50 Hz, 10 poles, 600	(15)	BTL6	Creating	CO4

	rpm, Y connected induction motor, Bav = 0.48 Wb/m2, ac = 28,000 amp.cond/m, L/τ = 1.25, η = 0.9, power factor = 0.86.				
5.	Find the values od diameter and length of stator core of a 7.5 kW 220V, 50Hz, 4 pole, three phase IM for best power factor.	(15)	BTL4	Analyzing	CO4

UNIT-V DESIGN OF SYNCHRONOUS MACHINES

Output equations – Main Dimensions - choice of specific loadings – Design of salient pole machines – Short circuit ratio – shape of pole face - Armature design – Estimation of air gap length – Design of rotor –Design of damper winding – Determination of full load field MMF – Design of field winding – Design of turbo alternators -Computer program: Design of Stator main dimensions-Brushless DC Machines.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Name the two types of synchronous machines.	BTL1	Remembering	CO5
2.	What is the use of damper winding in synchronous alternator and synchronous motor?	BTL2	Understanding	CO5
3.	Define runaway speed of an alternator.	BTL1	Remembering	CO5
4.	List the types of poles used in salient pole machines.	BTL2	Understanding	CO5
5.	Prepare the list of factors to be considered for the choice of specific electric loading.	BTL3	Applying	CO5
6.	Define short circuit Ratio (SCR)	BTL3	Applying	CO5
7.	What is salient pole rotor? What is Alternator? What are the advantages of large Air-gap in synchronous machine?	BTL1	Remembering	CO5
8.	What are the constructional differences between salient pole type alternator and cylindrical rotor type alternator?	BTL5	Evaluating	CO5
9.	State merits of Computer Aided Design of electrical machines.	BTL2	Understanding	CO5
10.	Why is length of airgap in an induction motor kept at minimum range?	BTL4	Analyzing	CO5
11.	State the important features of turbo alternator rotor.	BTL1	Remembering	CO5
12.	How is cylindrical pole different from salient pole in a synchronous machine?	BTL4	Analyzing	CO5
13.	How is computer aided design different from conventional design in the case of electrical apparatus?	BTL2	Understanding	CO5
14.	List the advantages of large air-gap in synchronous	BTL4	Analyzing	CO5

	machines.				
15.	What are the factors to be considered for the choice of specific magnetic loading in synchronous machines?		BTL3	Applying	CO5
16.	Define critical speed.		BTL1	Remembering	CO5
17.	List the advantages of large air-gap in synchronous machines.		BTL1	Remembering	CO5
18.	Write the expressions for length of air-gap in salient pole synchronous machine.		BTL6	Creating	CO5
19.	List the factors that govern the design of field system of alternator.		BTL6	Creating	CO5
20.	Explain how the value of SCR affects the design of alternator?		BTL5	Evaluating	CO5
21.	State the reason - length of airgap in an induction motor kept at minimum range?		BTL1	Remembering	CO5
22.	Sketch the merits of large air-gap in synchronous machines.		BTL2	Understanding	CO5
23.	Articulate the factors to be considered for the choice of specific magnetic loading in synchronous machines?		BTL3	Applying	CO5
24.	Analyze how cylindrical pole is different from salient pole in a synchronous machine?		BTL4	Analyzing	CO5
	PART-B				
1.	Mention the factors that govern the design of field system alternator.	(13)	BTL1	Remembering	CO5
2.	Sketch the shape of a salient pole rotor and cylindrical rotor. What are the constructional differences between salient pole type alternator and cylindrical rotor type alternator?	(13)	BTL2	Understanding	CO5
3.	A 1000kVA, 3300V, 50Hz, 300rpm, 3-phase alternator has 180 slots with 5 conductors/ slot, single layer winding with full pitched coil is used. The winding is star connected with 1 circuit per phase. Determine the specific electric and magnetic loading, if the stator bore is 2.0m and the core length is 0.4m. Using the same loading determine corresponding data for a 1250kVA, 3300V, 50Hz, 250rpm, 3-phase star connected alternator having 2 circuit per phase. The machines have 60^{o} phase spread.	(13)	BTL3	Applying	CO5
4.	State and explain the main factors which	(13)	BTL2	Understanding	CO5

	influence the choice of specific magnetic loading and specific electric loading in a synchronous machine.				
5.	Derive output equation of synchronous machine.	(13)	BTL1	Remembering	CO5
6.	For a 250kVA, 1100V, 12 pole 500rpm, 3-phase alternator. Determine the airgap diameter, core length, No. of stator conductors, No. of stator slots and cross section of stator conductors. Assuming average gap density as 0.6wb/sq.m. and specific electric loading of 30000 amp.cond./m. pole arc to pole pitch is 1.5.	(13)	BTL3	Applying	CO5
7.	Identify the main dimension for 1000 kVA, 50 Hz, three phase, 375 rpm alternator. The average air gap flux density = 0.55 wb/m2 and ampere conductors / m = 28000. Use rectangular pole. Assume a suitable value for L / τ in order that bolted on pole Construction is used for which machine permissible peripheral speed is 50 m/s. The runway speed is 1:8 times synchronous speed.	(13)	BTL4	Analyzing	CO5
8.	Find main dimension of 100 MVA, 11 KV, 50 Hz, 150 rpm, three phase water wheel generator. The average gap density = 0.65 wb/m2 and ampere conductors / m are 40000. The peripheral speed should not exceed 65 m/s at normal running speed in order to limit runaway peripheral speed.	(13)	BTL1	Remembering	CO5
9.	Describe a suitable number of slots conductors / slot for stator winding of three phase,3300V, 50 Hz, 300 rpm alternator, the diameter is 2.3m and axial length of core = 0.35 m. Maximum flux density in air gap should be approximately 0.9 wb / m2. Assume sinusoidal flux distribution use single layer winding and star connection for stator.	(13)	BTL2	Understanding	CO5
10.	A 2000 kVA, 3300V, 50Hz, 300 rpm, three phase alternator has 180 slots with 5 conductors/slot, single layer winding with full pitch coil is used. The winding is star connected with	(13)	BTL1	Remembering	CO5

	one circuit / phase. Evaluate specific electric loading and magnetic loading, IF stator core is 0.2 m and core length = 0.4 m. Using same loading determine the data for 1250 kVA, 3300V, 50 Hz, 250 rpm, three phase star connected alternator having 2 circuits / phase.				
11.	Evaluate for a 15 MVA, 11kV, 50 Hz, 2pole, star connected turbo alternator (i) air- gap diameter, (ii) core length, (iii) number of stator conductors, from the given data Bav= 0.55 wb/sq.m, ac=36000amp.cond/m, δ=5A/sq.mm, synchronous speed ns=50rps, Kws=0.98, peripheral speed=160m/s.	(13)	BTL4	Analyzing	CO5
12.	Evaluate the main dimensions of stator core for an 8 pole alternator rated at 3300KVA, 300V, 50Hz. Assume specific electric loading to be 28000 ac/m and magnetic loading to be 0.6wb/sq.m, pole arc=0.65*pole pitch. Assume square pole.	(13)	BTL3	Applying	CO5
13.	Identify the main dimensions of a 12MVA, 13.8KV, 50Hz, 1500rpm 3 phase star connected alternator. Bav= 0.6 Tesla, ac/m = 42000, peripheral speed = 80m/s. Find also the maximum flux, number of stator slots if one conductor per slot is used number of turns per phase.	(13)	BTL5	Evaluating	CO5
14.	The field coils of a salient pole alternator are wound with a single layer winding of bare copper strip 30mm depth with separating insulation of 0.15mm thick. Analyze winding length, no.of.turns and thickness of conductor to develop an mmf of 1200AT with a potential difference of 5V per coil and with a loss of 1200W/sq.m of total coil surface. The mean length of turn is 1.2m. The resistivity of copper is 0.021Ω/m	(13)	BTL6	Creating	CO5
15.	Describe the construction of turbo alternator with neat sketch.	(13)	BTL1	Remembering	CO5
16.	For a 250kVA,2200V, 12 pole, 500 rpm,3 phase alternator, determine core diameter and core	(13)	BTL2	Understanding	CO5

	length. Assuming average gap density as $0.6 wb/m^2$ and specific electric loading of 30000 amp.cond/m,L/ι=1.5.				
17.	Illustrate the steps required for the design of damper winding of synchronous machine and show the position of damper bars in a diagram	(13)	BTL3	Applying	CO5
	PART-C				
1.	A 1000kVA, 3300V, 50Hz, 300rpm, 3-phase alternator has 180 slots with 5 conductors/ slot, single layer winding with full pitched coil is used. The winding is star connected with 1 circuit per phase. Determine the specific electric and magnetic loading, if the stator bore is 2.0m and the core length is 0.4m. Using the same loading determine corresponding data for a 1250kVA, 3300V, 50Hz, 250rpm, 3-phase star connected alternator having 2 circuit per phase. The machines have 60^o phase spread.	(15)	BTL5	Evaluating	CO5
2.	Identify the output coefficient for a 1500kVA, 2200 Volts,3 phase,10 pole,50Hz,Star connected alternator with sinusoidal flux distribution.The winding had 60° phase spread and full pitch coils. ac=30000 amp.cond/m, Bav=0.6 Wb/m^2.If the peripheral speed of the rotor must not exceed 100m/sec and the ratio pole pitch to core length is to be between 0.6 and 1,find D and L. Assume an airgap length of 6mm.Find also the approximate number of stator conductors.	(15)	BTL5	Evaluating	CO5
3.	Identify for 500kVA, 6600V, 20Hz, 500 rpm and connected three phase salient pole machine diameter, core length for square pole face number of stator slots and number of stator conductors for double layer winding. Assume specific magnetic loading = 0.68 tesla, ac = 30000 AC/m and Kws = 0.955.	(15)	BTL6	Creating	CO5
4.	Find the main dimensions of a 2500 KVA, 187.5 rpm, 50Hz,3 phase, 3KV, salient pole alternator. The generator is to be vertical water wheel type. Use circular pole with ratio of core length to pole	(15)	BTL6	Creating	CO5

	pitch=0.65. Specify the type of pole construction used if the runaway speed is about 2 times the normal speed.				
5.	Determine the main dimensions of a 75000 KVA, 13.8KV, 50Hz, 62.5rpm, 3 phase star connected alternator. The peripheral speed is about 40m/s. Assume average gap density=0.65wb/m^2, ampere conductors/metre= 40,000 and current density=4A/mm^2. Also find the no. of stator slots, conductors per slot, conductor area. Assume slot pitch= 55mm.	(15)	BTL4	Analyzing	CO5

Course Outcome:

- Engineering students will acquire the basic knowledge of Magnetic circuit parameters and thermal rating of various types of electrical machines.
- Students will have an understanding on the evolution of Core, yoke, windings and cooling systems of transformers and the importance of computer aided design method.
- Students will be able to show an understanding on Armature and field systems for D.C. machines and computer aided design method.
- Students will be able to advocate on Design of stator and rotor of induction machines and computer aided design method
- Students will have understanding on the Design of stator and rotor of synchronous machines and the computer aided design method.