CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET394	GENERALIZED MACHINE THEORY	VAC	4	0	0	4

Preamble: Nil

Prerequisite: DC Machines and Transformers. Synchronous and Induction machines

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory.
CO 2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance.
CO 3	Apply linear transformation for the steady state and transient analysis of different types of rotating electrical machines.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	2	-	-	-	-	-	-	-	-	**2**
CO 2	3	3	2	**2**	-	-	-	-	-	-	-	**2**
CO 3	3	3	3	**2**	-	-	-	-	-	-	-	**2**

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Kron's Primitive Machine of rotating electrical machines.
2. Describe the essential features of rotating electrical machines.
3. Draw the basic two pole machine diagram of DC Compound Machine.
4. Develop an expression for the electrical torque of the Kron's Primitive Machine.

Course Outcome 2 (CO2):

1. What are the advantages of having power invariance in transformations.
2. Deduce Parks transformations relating three phase currents to its corresponding d- q axis currents.
3. Draw the generalized model of a DC series machine and derive the voltage equation in matrix form.
4. Explain the physical significance of Park's transformations.

Course Outcome 3 (CO3):

1. Explain the steady state analysis of a separately excited DC motor and derive the expression for electromagnetic torque. Also plot the shunt characteristics and speed versus armature voltage characteristics.
2. Obtain the expression for the steady state torque when balanced poly phase supply is impressed on the stator winding of three phase Induction motor
3. Draw the equivalent circuit of a three phase induction motor with the help of its generalized model.
4. Investigate the transient behaviour of a separately excited DC generator under the following operating condition: sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ω_{r0} and explore the variation of armature voltage.

Model Question paper

QP CODE:

PAGES: 2

Reg.No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET394
Course Name: GENERALIZED MACHINE THEORY

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. Sketch the basic two pole representation of the following machines
   i) DC shunt machine with interpoles ii) DC compound machine
2. Explain linear transformations as used in electrical machines.
3. What is Kron's primitive machine?
4. Enumerate the limitations of generalized theory of electrical machines.
5. Derive an expression for rotational mutual inductance or motional inductance of DC generator
6. Derive the transfer function of separately excited DC motor under on no load operation.
7. Draw the power angle characteristics of salient pole and cylindrical rotor synchronous machine.
8. Draw the torque slip characteristics of three phase Induction motor.
9. Explain equivalent circuit of single phase Induction motor.
10. Compare single phase and poly phase Induction motor.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Write the voltage equations for Kron's primitive machine in matrix form. **(9)**
    b) Derive the expression for transformer and speed voltages in the armature along the quadrature axis. **(5)**
12. Derive electrical torque expression of Kron's primitive machine in terms of reluctance and show that no torque is produced by interaction between flux and current on the same axis. **(14**

Module 2

13. Explain Park's transformations to transform currents between a rotating balanced three phase (a, b, c) winding to a pseudo stationary two phase (d, q) winding. Assume equal number of turns on all coils **(14)**

14. a) Explain the physical concept of Park's transformation **(7)**

b) Explain the term invariance of power as applied to electrical machines. Show the power invariance is maintained under this transformation. **(7)**

Module 3

15. a) Derive the voltage and torque equation of a DC series motor from its generalized mathematical model. **(7)**

b) Obtain the steady state analysis of a separately excited DC motor and plot the shunt characteristics. Also derive the expression for torque. **(7)**

16. a) A separately excited DC generator gives a no load output voltage of 240 V at a speed of ωr and a field current of 3 A. Find the generated emf per field ampere, Kg. **(5)**

b) Investigate the transient behaviour of a separately excited DC generator under the following operating condition:

i) Sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ωr0 and explore the variation of armature voltage. **(9)**

Module 4

17) a) Derive the power expression for salient pole synchronous machine in terms of load angle δ and draw the power angle characteristics. **(7)**

b) Derive the voltage equations in matrix form for a three phase synchronous machine with no amortisseurs. **(7)**

18) Derive the equivalent circuit of a poly phase induction motor with the help of its generalized mathematical model. **(14)**

Module 5

19) Derive the electromagnetic torque equations from the primitive machine model of a single phase induction motor by applying cross field theory. **(14)**

20) Explain the double field revolving theory of single phase Induction motor. **(14)**

Syllabus

Module 1

Unified approach to the analysis of electrical machine performance - per unit system - Basic two polemodel of rotating machines- Primitive machine -Conventions -transformer and rotational voltages in the armature voltage and torque equations, resistance, inductance and torque matrix.

Module 2

Transformations-passive linear transformation in machines-invariance of power-transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Physical concept of Park's transformation.

Module 3

DC Machines: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics.

Module 4

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves.

Induction Machines: Primitive machine representation. Transformation- Steady state operation-Equivalent circuit. Torque slip characteristics.

Module 5

Single phase induction motor- Revolving Field Theory equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor.

Text Books

1) Bhimbra P. S., “Generalized Theory of Electrical Machines”, Khanna Publishers, 6thedition, Delhi 2017.
2) Charles V. Johnes, “Unified Theory of Electrical Machines”. New York, Plenum Press, 1985.
3) Bernad Adkins, Ronald G Harley, “General theory of AC Machines”. London, Springer Publications, 2013.

Reference Books

1) Charles Concordia,” Synchronous Machines- Theory and Performance”, John Wiley and Sons Incorporate, Newyork.1988.
2) Say M. G., “Introduction to Unified Theory of Electrical Machines”, Pitman Publishing, 1978.

3) Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Two pole Model (10 Hours)**	
1.1	Introduction- Essentials of rotating machines-Electromechanical energy conversion. Conventions.	1
1.2	Idealised machine diagram of DC Compound machine, DC shunt machine, Synchronous motor, Induction motor, Single phase AC motor.	2
1.3	Per unit system, Advantages of per unit system, Expression for self inductance of a machine, Mutual flux linking.	1
1.4	Transformer and speed voltages in the armature, transformer with movable secondary.	2
1.5	Kron's primitive machine, Leakage flux in machines with more than two windings. Fundamental assumptions.	2
1.6	Voltage equations, Stator field coils, Armature coils, Equations of armature voltage in matrix form,	2
2	**Linear Transformations (8 Hours)**	
2.1	Linear transformation in machines- power invariance, Transformations from a displaced brush axis.	2
2.2	Transformations from three phase to two phase (a,b,c) to (α,β,0) transformation matrix.	3
2.3	Transformation from rotating axes (α,β,0) to stationary axes (d,q,0).	2
2.4	Power invariance: problems on transformations	1
3	**DC Machines (10 Hours)**	
3.1	DC machines, Separately excited DC generators, Rotational mutual inductance, Steady state and transient analysis, Armature terminal voltage.	2
3.2	Transfer function of DC machines, Separately excited generator under no load and loaded condition, Numerical Problems.	2
3.3	Steady state analysis and Shunt characteristics of DC machine.	2

3.4	DC series motor, Schematic diagram of Primitive model, Interconnection between armature and field, Torque and speed expression, Different characteristics.	2
3.5	DC shunt motor, Schematic diagram, primitive model, Steady state analysis, Torque-Current and Speed-Current characteristics, Condition for maximum torque.	2
4	**Synchronous and Three Phase Induction Motors(10 Hours)**	
4.1	Poly phase Synchronous machine, Basic structure, Assumptions, Parameters, Synchronous resistance, inductance and mutual inductance between armature and field.	2
4.2	Armature self-inductance, Armature mutual inductance, General synchronous machine parameters, Amplitude of second harmonic component.	2
4.3	Steady state power angle characteristics, reluctance power, Cylindrical rotor machine and salient pole machine, Phasor diagram, Pull out torque, Maximum power.	2
4.4	Polyphase induction machine, Voltage expression, Transformations from$\alpha\beta$ to d-q and vice versa, Expression for electromagnetic torque.	2
4.5	Steady state analysis, Voltage equation in new variables, Connection matrix,	1
4.6	Equivalent circuit of an induction machine, Short circuited and open circuited two winding transformer.	1
5	**Single Phase Induction Motors(7 Hours)**	
5.1	Single phase induction motor, Basic structure, Assumptions, Primitive Machine Model.	2
5.2	Electrical Performance Equations, Voltage Matrix.	2
5.3	Steady state analysis, Equivalent Circuit	2
5.4	Numerical Problems	1