Techno India NJR Institute of Technology

Course File

Electrical Machines – II (4EE4-05)

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Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - IV Semester: B.Tech. (Electrical Engineering)

4EE4-05: Electrical Machines – II

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Fundamentals of AC machine windings** Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor.	7
3	**Pulsating and revolving magnetic fields** Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.	4
4	**Induction Machines** Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.	12
5	**Single-phase induction motors** Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications.	6
6	**Synchronous machines** Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine – two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.	10
	Total	**40**

Course Overview:

The course will begin with explaining basic underlying principles of working of various types of electrical rotating machines. The conditions to be fulfilled for the steady production of electromagnetic torque (Te). Motoring and generating mode of operation. Primary focus will be on the operation of 3-phase induction machine, single phase induction motor, and synchronous machines. A fair knowledge of distributed windings is essential in order to understand the working of rotating machines more effectively – few lectures will be devoted on this topic. Concept of electrical and mechanical angles will be explained. Nature of magnetic flux distribution along the air-gap of a rotating machine will be discussed. Clear concept of Rotating magnetic field is so important in understanding the operation of induction and synchronous machines. For each of this machine equivalent circuit will be derived and then used to derive expression for the torque. Starting, speed control and electrical braking of the motors will be discussed. Although main focus will be on the steady state performance analysis, few cases of important transient analysis will be discussed. Students will be motivated to solve numerical problems logically and efficiently.

In industries, power conversion plays a vital role as industry machinery operates at different voltage levels. Hence, the study of the transformer becomes very important. Every industry uses electrical machines to do certain work in production, so this course will help students understand the Motion Control industry's requirements. The course is also important for upcoming course subjects and prerequisite for those subjects.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	The student will be able to explain the construction, working principle, performance and applications of Poly-phase induction machine, Single phase motors, synchronous generator (Alternator) and synchronous motor.
2	Synthesis	The student will be able to identify, formulate and solve the numerical problems related to above machines.
3	Analysis	Students will be able to analyze the performance characteristics for different electrical machines and obtain simple equivalent circuit for the machine.

4	Synthesis	Students will be able to explain different testing and starting methods for electrical machines so as to identify their applicability in different practical situations.
5	Application	Students will be able to show the purpose for parallel operation of synchronous generators and illustrate the conditions to be satisfied for this.

Prerequisites:

1. Basic Electrical Technology and elementary calculus.
2. AC and DC electrical theory and a good understanding of magnetism.
3. Students should have at least a basic knowledge of electric circuit analysis and vector calculus.
4. A good grasp over Linear Algebra and Complex Analysis.

Course Outcome Mapping with Program Outcome:

Course Outcome	**Program Outcomes (PO's)**											
CO. NO.	**Domain Specific (PSO)**					**Domain Independent (PO)**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	2	1	1	-	-	-	-	-	-	-
CO2	2	1	1	2	1	-	-	-	-	-	-	-
CO3	1	2	2	1	2	-	-	-	-	-	-	-
CO4	2	1	2	1	1	-	-	-	-	-	-	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**INTRODUCTION:** Objective, scope and outcome of the course.
2	**2**	**FUNDAMENTALS OF AC MACHINE WINDINGS:** Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn coil – active portion and overhang
3	2	Full-pitch coils, concentrated winding, distributed winding, winding axis
4	2	3D visualization of the above winding types
5	2	Air-gap MMF distribution with fixed current through concentrated winding
6	2	Air-gap MMF distribution with fixed current through distributed winding

7	2	Sinusoidally distributed winding, winding distribution factor.
8	2	Numerical on distributed windings and winding distribution factor
9	2	Numerical on full-pitch coils, concentrated winding, distributed winding
10	**3**	**PULSATING AND REVOLVING MAGNETIC FIELDS:** Constant magnetic field, pulsating magnetic field – alternating current in windings with spatial displacement
11	3	Magnetic field produced by a single winding – fixed current and alternating current Pulsating fields produced by spatially displaced windings
12	3	Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields
13	3	Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents)
14	3	Revolving magnetic field
15	**4**	**INDUCTION MACHINES:** Construction, Types (squirrel cage and slip-ring)
16	4	Torque Slip Characteristics
17	4	Starting and Maximum Torque. Equivalent circuit
18	4	Phasor Diagram, Losses and Efficiency
19	4	(Cont.) Phasor Diagram, Losses and Efficiency
20	4	Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency)
21	4	(Cont.) Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency)
22	4	Methods of starting
23	4	(Cont.) Methods of starting
24	4	Braking and speed control for induction motors
25	4	(Cont.) Braking and speed control for induction motors
26	4	Generator operation and Self excitation
27	4	Doubly-Fed Induction Machines.
28	4	Numerical on starting torque and maximum torque
29	4	Numerical on Equivalent circuit Losses and Efficiency
30	4	Numerical on starting and braking
31	**5**	**SINGLE-PHASE INDUCTION MOTORS:** Constructional features
32	5	Double revolving field theory
33	5	Equivalent circuit, determination of parameters

34	5	Split-phase starting methods
35	5	Applications of Single-phase induction motors
36	5	Numerical on single phase induction motor
37	**6**	**SYNCHRONOUS MACHINES:** Constructional features, cylindrical rotor synchronous machine
38	6	Generated EMF, equivalent circuit and phasor diagram
39	6	Armature reaction
40	6	Synchronous impedance, voltage regulation
41	6	Operating characteristics of synchronous machines
42	6	V-curves
43	6	Salient pole machine- two reaction theory
44	6	Analysis of phasor diagram, power angle characteristics
45	6	Parallel operation of alternators – synchronization and load division
46	6	Numerical on generated EMF and equivalent circuit
47		Revision to course work
48		Revision to course work

Text/Reference Books:

1. E. Fitzgerald, C. Kingsley Jr and Umans, Electric Machinery, 6th Edition McGraw Hill, International Student Edition.
2. Kothari & Nagrath, Electric Machines 3/e,TMH
3. M. G. Say, The Performance and Design of AC machines, Pit man & Sons.
4. Guru, Electric Machinery 3e, Oxford

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/105/108105131/
Quiz	https://quizizz.com/admin/quiz/5e99f407a0907f001eeb0584/electrical-machine
Notes	https://sites.google.com/site/reddyeeenotes1/updates/MACHINES2NOTES%20by%20REDDY.pdf?attredirects=0&d=1 https://sites.google.com/site/eeenotes2u/courses/electrical-machines-1-2

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous Year Question Paper

4E4175

Roll No. Total No of Pages: 4

4E4175

B. Tech. IV Sem. (Back) Exam., May - 2019

Electrical Engineering

4EE5A Electrical Machines - II

Time: 3 Hours **Maximum Marks: 80**
Min. Passing Marks: 26

Instructions to Candidates:

*Attempt any **five questions**, selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. Graph Paper 2. NIL

UNIT- I

Q.1 (a) How can we eliminate r^{th} normonic by using short pitch winding? [4]

(b) What are the advantages of distributed winding? [4]

(c) 3ϕ, 16 poles, Synchronous Generator has resulting air gap flux of 0.06 wb/pole. The flux is distributed sinusoidally over the pole. The stator has 2 slots per pole per phase and 4 conductors per slot are accommodated in two layers the coil span is 150° electrical. Calculate the phase and line voltage when machine rms at 325 rpm. [8]

OR

Q.1 (a) Proof - [8]

$Q_m = \frac{2}{p} Q_e$

$Q_m =$ Angle of rotation (mechanical)

$Q_m =$ „ „ „ (electrical)

(b) Also proof graphically if we interchange the terminal of 2 – phase supply the direction of R.M.F. (rotating magnetic field) [8]

UNIT - II

Q.2 (a) Why iron losses are neglected on rotor side in 3 - ϕ I. M. [4]

(b) How can we separate the iron losses and friction and wind age losses in 3 - ϕ I. M.? http://rtuonline.com [4]

(c) Why starter is not used in slip ring induction motor? [2]

(d) Why low slip region is called stable region and high slip region is called unstable region in torque slip characteristic? [6]

OR

Q.2 Draw the circle diagram from no load to and S.C. test of a 3 - ϕ, 14.92 kW, 400V, 6 pole I. M. from the following test result (lime values) [16]

No load :	400 – V	11A	p.f. =	.2
Short Circuit	100 – V	25 A	p.f. =	.4

Rotor cu – losses at stand – still the half the total cu – losses.

From the diagram find out –

(a) line current slip, efficiency and p.f. at full load

(b) Max torque

UNIT- III

Q.3 (a) How can we perform block rotor test in 1 -ϕ inducation motor. Also draw the equivalent electrical circuit diagram during this condition? [8]

(b) Explain the basic principle of stapper motor. [8]

OR

Q.3 (a) What is the reason that single phase induction motor is not self starting? [4]

(b) What is the use of copper ring in pole show in phase split induction motor? [4]

(c) Explain the basic principle of single phase synchronous motor. [8]

UNIT- IV

Q.4 (a) What is the operating region of synchrmonous generator during full load condition. (according to B – H curve) [4]

(b) Proof $X_d \geq X_q$ [4]

Where X_d = direct axis reactance

X_q = Quadrature axis reactance

(c) Write down the all step of MMF methods. Also draw the phasor diagram if we igone the armature resistance. [8]

OR

Q.4 (a) Draw the graph between Z_s v/s I_f [4]

Where Z_s = synchronous impedance

I_f = field current

(b) Also explain the reason why is "passimastic result" obtained in the voltage regulation by using synchronous impedance method. [4]

(c) What are the necerrary and sufficient conditions for synchronizing of altermators. [8]

UNIT- V

Q.5 (a) Why synchronous motor is not self starting? [6]

(b) Draw the torque slip characteristic of synchronous motor. [4]

(c) What is the impact of change in load on armature current and P. F. (Power factor) during normal excitation. Draw the phasor diagram. [6]

OR

Q.5 (a) 20 pole, 693V, 50 Hz, 3 ϕ, y connected synchronous motor is operating at no load and synchronous reactance of 10Ω (assuming $R_a = 0$) if rotor is returned by 0.5° (mech.) from its synchronous position. Compute [14]

(i) Rotor displacement in electrical degree.

(ii) Armature EMF/phase

(iii) Armature current.

(iv) Power drawn by motor

(v) Power develop by armature.

How will these quantities change when motor is lodded and displaced by 5° (mech.)

(b) If the load is dead constant on operating condition then how much induced E.M.F. is induced in damper bar/winding. [2]