GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Subject Code: ME02000731
Course / Subject Name: Modeling of Electrical Machines

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	PCC

Prerequisite:	Fundamentals of Electrical Machines
Rationale:	This subject deals with the mathematical modeling of the Electrical machines and their applications. Such models are helpful to analyze dynamic response of the plants/systems equipped with electrical machines. In order to analyze the power system stability and to design appropriate controllers, these models are essential. Transient stability analysis of large power system networks is done through digital computers. In order to simulate/analyze the system using digital computers, it is essential to obtain the mathematical model of the system.

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Derive the mathematical models of electrical machines to obtain its dynamic response	20
CO-2	Analyze the transient behaviour of the symmetrical induction machines with different load and fault conditions using standard modeling techniques	20
CO-3	Examine the dynamic response of the synchronous machine during steady state as well as transient conditions with the disturbances like faults, sudden load change, line outage, excitation failure etc..	20
CO-4	Evaluate the operational characteristics and performance parameters of special electrical machines under diverse operating conditions	20
CO-5	Apply various programing, simulation and analysis tools to infer the strategies related to efficient operation and control of the electrical machines.	20

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr No.	Topics	Total Hours	% weightage.
1	**Basic principles for Electrical Machine Modeling:** Introduction, Magnetically coupled circuits, Electromechanical energy conversion, Machine Windings & Airgap MMF, Winding Inductances & Voltage Equations.	07	15
2	**Reference frame theory:** Introduction, Equations of transformation-change of variables, Stationary circuit variables transformed to the arbitrary reference frame, Commonly used reference frames and transformation between reference frames, Transformation of a balanced set, Balanced steady state phasor relationships and voltage equations, Variables observed from various frames of reference.	08	10
3	**Symmetrical Induction machines:** Voltage and torque equations in machine variables, Equation of transformation for rotor circuits, Voltage & torque equations in arbitrary reference frame variables, Per unit system, Analysis of steady state equations, Free acceleration characteristics viewed from various reference frames, Dynamic model and analysis for sudden change in load torque, Dynamic model & analysis during three phase fault at the machine terminals, Unbalanced operation of symmetrical Induction Machines,Symmetrical component theory and analysis of unbalanced stator voltages, Analysis of steady state operation with unbalanced rotor conditions.	10	25
4	**Synchronous machines:** Voltage & torque equations in machine variables, Stator voltage equations in arbitrary reference frame variables, Voltage equations in rotor reference frame variables-Park's transformation, Torque equation in transformed variables, rotor angle and angle between rotors, Per unit system, analysis of steady state operation, Dynamic performance during a sudden change in input torque, excitation, load. Analysis of the machine with fault at the machine terminals.	10	25

5	**Modeling and Analysis of Special Machines:** • Permanent magnet synchronous machines • Surface Permanent Magnet (square and sinusoidal back emf type) and Interior Permanent Magnet machines • Switched Reluctance Motors. • Brushless D.C. Motor	**10**	**25**
	TOTAL	**45**	**100**

Reference Books:

1. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, New York
2. Charles Kingsle,Jr., A.E. Fitzgerald, Stephen D.Umans, "Electric Machinery", Tata Mcgraw Hill
3. R. Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", Prentice Hall of India
4. Miller, T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press
5. Chee-Mun, "Dynamic Simulation of Electric Machinery using MATLAB", Prentice Hall PTR
6. K. R. Padiyar, "Power System Dynamics Stability and Control", B S Publications
7. P. Kundur, "Power System Stability & Control", Tata Mcgraw hill

List of Experiments:

1. Prepare a simulation/program to transform a 3-phase balanced system in to dq0 variables.
2. Prepare a simulation/program to transform a 3-phase unbalanced system in to dq0 variables.
3. Prepare a simulation/program to observe the effect of reference frame transformation on the frequency of the transformed variables.
4. Prepare a simulation/program to convert variables from one reference frame to another.
5. Prepare a simulation of induction machine in qd0 form and analyze the transient response with different disturbances like step change in load, unbalanced voltages etc..
6. Prepare a simulation of synchronous machine in qd0 form and analyze the transient response with different disturbances like step change in input torque, excitation, load etc..
7. Obtain the transient response using the simulation of synchronous machine in dq0 form for the short circuit at its terminals.
8. Prepare the simulation of Surface Permanent Magnet and Interior Permanent Magnet machines
9. Prepare the simulation of Switched Reluctance Motor (SRM).
10. Prepare the simulation of Brushless DC (BLDC) motor.

Major Equipment: Simulation software like MATLAB along with necessary toolbox, PSIM, PSCAD or Scilab

List of Open Source Software/learning website:

E-materials available at the website of NPTEL- http://nptel.ac.in/

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