

GUJARAT TECHNOLOGICAL UNIVERSITY

POWER ELECTRONICS & ELECTRICAL DRIVES (45)

MODELING AND ANALYSIS OF ELECTRICAL MACHINES

SUBJECT CODE: 3712916

M.E. 1st SEMESTER

Type of course: Engineering Science (**ELECTRICAL**)

Prerequisite: Electrical Machines

Rationale: N.A.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Principles of Electromagnetic Energy Conversion General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.	7	15
3	Introduction to Reference Frame Theory Static and rotating reference frames, transformation relationships, examples using static symmetrical three phase R, R-L, R-L-L and R-L-C circuits, application of reference frame theory to three phases symmetrical induction and synchronous machines, dynamic direct and quadrature axis mode in arbitrarily rotating reference frames, voltage and torque equations, derivation of steady state phasor relationship from dynamic model, generalized theory of rotating electrical machine and Kron's primitive machine.	11	25
4	Analysis of Induction Machines Induction machine equations in phase quantities assisted by space vectors-sinusoidal distributed winding; stator single-phase magnetizing and mutual inductance; per-phase magnetizing inductance; equivalent winding in a squirrel-cage rotor and rotor inductances; review of space vectors; flux-linkage and voltage equations in terms of space vectors. Dynamic analysis in terms of dq windings-stator and rotor dq windings and inductance-flux linkage and voltage equations in dq coordinates, electromagnetic torque; dq equivalent circuits; computer simulation model.	12	30

5	<p>Modelling of Permanent Magnet Synchronous Machines and Permanent Magnet Brushless DC Motor</p> <p>Permanent magnet synchronous machines: Surface permanent magnet and interior permanent magnet machines, construction and operating principle, real-time model of a two-phase PMSM, transformation to rotor reference frames, three-phase to two-phase transformation, unbalanced operation, zero sequence inductance derivation, power equivalence, electromagnetic torque, steady-state torque characteristics, models in flux linkages, equivalent circuits</p> <p>Permanent Magnet Brushless DC Motor: Construction and operating principle, PM Brushless DC Machine, Modelling of PM Brushless DC Motor, Normalized System Equations, The PMBLDC Motor Drive Scheme</p>	12	30
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Reference Books:

1. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, New York, 2004.
2. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans "Electric Machinery", Tata McGraw Hill, Fifth Edition, 1992.
3. ONG, Chee-Mun, "Dynamic Simulation of Electric Machinery using MATLAB", Prentice Hall PTR
4. Generalized theory of electrical machines by P S Bimbhra, 5th edition, Khanna Publishers Delhi
5. R. Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", Prentice Hall of India, 2001.
6. Ned Mohan, "Advanced electrical drives Analysis, Control and Modeling using Simulink", MNPERE, Minneapolis, USA, 2001.
7. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London, 1967.
8. Miller, T.J.E. "Brushless permanent magnet and reluctance motor drives" Clarendon Press, Oxford, 1989.
9. O'Simmons and Kelly, "Introduction to Generalized Machine Theory". McGraw-Hill, 1968
10. Hancock, "Matrix Analysis of Electric Machinery". Pergamon, Oxford, U.K., 1964
11. Mritunjay Bhattacharyya, "Electrical Machines : Modelling and Analysis" Prentice Hall
12. J. Meisel, "Principles of Electromechanical Energy Conversion" McGraw Hill, 1966.

Course Outcomes:

After learning the course, the students should be able to:

1. Understand significance of electromagnetic energy conversion. (Understand)
2. Find different mathematical parameters of rotating machine. (Apply)
3. Apply reference frame theory to different electrical machines. (Apply)
4. Develop mathematical model of an induction machine. (Evaluate)
5. Analyze the performance of different types of electrical machine and its design parameters. (Analyze)

List of Experiments

1. Modelling and simulation of variable frequency oscillator in MATLAB
2. Modelling and simulation of series-parallel RLC circuit
3. To implement change of variables ($3 - \phi$ to $2 - \phi$) in MATLAB simulation
4. To implement change of variables ($2 - \phi$ to $3 - \phi$) in MATLAB simulation
5. To implement flux equation of induction machine in arbitrary reference frame in MATLAB simulation.
6. To implement current equation of induction machine in arbitrary reference frame in MATLAB simulation
7. To implement torque equations of induction machine in arbitrary reference frame variable in MATLAB
8. To simulate and observe free acceleration characteristics of induction machine
9. To observe dynamic performance of induction machine during sudden changes in load torque
10. Simulation of BLDC motor
11. Analyze the dynamic performance of PMSM

Web-Link

1. nptel.ac.in/courses/108106023/
2. <http://people.ece.umn.edu/users/riaz/>