GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (07)

ELECTRICAL DRIVES

SUBJECT CODE: 2710709

SEMESTER: I

Type of course: Engineering

Prerequisite: Fundamentals of electromagnetics; Basic knowledge of power electronics and electrical machines

Rationale: The course on Electric Drives is designed to introduce the concept of control of electric drives for various types of mechanical loads. In this course, mainly the dc motor, induction motor and synchronous motor steady-state modeling and steady state torque and speed control of these motors are emphasized. The course exposes the applications of semiconductor controlled converters to control the DC and AC machines for better torque and speed response

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	PA (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Fundamentals of Electrical Drives** Dynamics of electrical drives, components of load torque, classification of load torque, concept of multi-quadrant operation, steady-state stability criteria.	4	10
2	**DC Drives with phase controlled converters** 1-phase fully controlled converter fed separately excited DC motor, modes of operation, steady-state motor performance equations, mode identification, speed-torque characteristics, operation with controlled fly-wheeling; operation with 1-phase half controlled converter; 3-phase fully controlled converter fed separately excited motor; Pulse width modulated rectifiers, equal pulse-width modulation, sinusoidal pulse width modulation; current control; multi-quadrant operation of fully-controlled converter fed DC motor; Dual converters based drives; Closed loop control of DC drives.	10	25
3	**DC drives with dc-dc converters** Principle of Motoring operation of separately excited and series motor with DC-DC converter, Steady-state analysis for time ratio control and current limit control; Regenerative braking; Dynamic and composite braking; multi-quadrant operation with dc-dc converters	5	15
4	**Fundamental of Induction Motor (IM) and its control** Review of IM: Steady-state analysis of an Induction motor; Starting and Braking methods; Speed control methods: variable terminal	5	8

	voltage, variable frequency control, rotor resistance control, injection of voltage in the rotor circuit; operation with a current source: operation with fixed frequency, variable frequency control.		
5	**Control of IM with solid state converters** Control of IM using VSI : Six step inverter, PWM inverter, braking and multi-quadrant control, VVVF control Control of IM using CSI :Three-phase CSI, Braking, PWM in a thyristor CS inverter, PWM with GTO based CSI, Variable frequency drives, Comparison of CSI and VSI based drives. Current controlled PWM inverters AC voltage controllers : AC voltage controller circuits, four quadrant control and closed-loop operation; fan/pump and crane/hoist drives; ac voltage controller starters Slip power controlled IM dirves: analysis of stator rotor resistance control, Static scherbius drive: power factor considerations, rating and applications, performance	15	30
6	**Synchronous motor drives** Wound field cylindrical rotor motor, equivalent circuits, operation with constant voltage and frequency response : motoring and regenerative braking operations, power factor control and V-curves, operation with current source; Wound field salient pole motor; operation with variable voltage source and constant frequency; Starting and braking when fed from constant freq source; brushless excitation of wound field machines; Permanent magnet motor operating from a fixed frequency source; Operation with non-sinusoidal supplies.	6	12

****** Some topics (especially related to design) may be covered as a part of assignments/tutorials.

Reference Books:

1. G.K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, New Jersey, 1989.
2. G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publications, New Delhi, 1994.
3. B.K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, New Delhi, 2003.
4. Muhammad H. Rashid , "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India Ltd., New Delhi, 3rd ed., 2003.
5. P.C. Sen, "Thyristor DC Drives", John Wiley and Sons Ltd., New York, April 1981.
6. R. Krishnan, "Electical Motor Drives – Modeling, Analysis and Control", PHI Pvt. Ltd., New Delhi, 2003.
7. W Leohnard, "Control of Electric Drives", Springer, 2001.
8. J.M.D. Murphy and F.G. Turnbull, "Power Electronic Control of AC motors", Pergamon Press, 1989.
9. M.D. Singh, K.B. Khanchandani, "Power Electronics", Tata McGraw-Hill, 2nd ed., 2006.
10. S. Dewan, B. Slemon, A. Straughen, "Power Semiconductor drives", John Wiley and Sons, NewYork 1984.
11. V. Subramanyam, "Electric Drives – Concepts and applications", Tata McGraw Hill Publishing Co., Ltd., New Delhi 2003.

Course Outcome:

After learning the course the students should be able to

1. Ability to analyze the steady state models of DC and AC motors
2. Ability to evaluate the different speed control methods on different performance parameters
3. Ability to describe and operate the DC and AC machines in different quadrants as per load requirements

4. Ability to determine the components of electrical drive for the required applications
5. Ability to select and design the power electronics converter based control logic for speed control of DC and AC motors

List of Experiments:

The experiments shall be based on the syllabus. A list suggesting some of the experiments that may be performed using simulation tools and/or experimental set-up are as under:

1. To study the various electrical drive system and identify its components operating on dc and ac supply.
2. To develop simulation model and analyze constant speed-variable torque dc drive system using conventional resistive control mechanism.
3. To develop simulation model and analyze constant speed-variable torque dc drive system using fully controlled converter in open loop mode.
4. To develop simulation model and analyze constant speed variable torque dc drive system using fully controlled converter in close loop mode.
5. To develop mathematical model for dc shunt and dc series motor in MATLAB using
    i. Power System Blockset
    ii. Mathematical toolbox
6. To design constant speed dc motor drive using chopper.
7. To study and identify various modes of operation in motoring/generating for dc shunt motor.
8. To study and simulate equal and sinusoidal PWM techniques for dc drives.
9. To develop mathematical model for 3-phase induction motor and to obtain various characteristics for
    i. Variable stator voltage
    ii. Variable stator/rotor resistance
    iii. Variable frequency
    iv. Constant V/f
10. To study the performance of a three phase induction motor fed from an inverter controlled in 120° and 180° conduction mode.
11. To study the performance and speed control of 3 phase slip ring Induction motor employing static rotor resistance controller.
12. To study the behavior of PWM inverter fed three phase induction motor (IM).
13. To study the controlled speed change/reversal of an induction motor using power converter.
14. To study performance of current controlled PWM inverters for ac drive applications.

Power Electronic Converter configuration can be specified by the instructor

Open Ended Problem:

Major Equipments:

Power Electronic Converters, Oscilloscopes (preferably DSO), Current Probe, Circuit Simulation Tools like MATLAB, PSIM or open source software to simulate power electronic converter circuits, and other basic equipment like meters, loads, motors etc.

List of Open Source Software/learning website:

http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Industrial%20Drives/index.htm
http://nptel.ac.in/courses/108108077/