

Electric Machines and Drives

Course Purpose:

The proposed course will focus on the fundamentals of electric machines and drives. Electric machines and drives are pervasive in industry and are the largest consumer of electrical energy. While the topic of electric machines and drives is broad, this course will focus on specific areas of interest consistent with robotics, machine tools, industrial automation, and electric vehicles. All four of these areas require servo control of the electric machine in order to meet the requirements of the application.

Course Description:

Servo control requires proper knowledge and understanding of electric machines and power electronic drives. This course gives fundamental principles of AC and DC drive systems including machine structures and driver topologies. The fundamentals of brush DC, Brushless DC (BLDC), PM synchronous, and induction machines are explored. In addition, inverter topologies and control techniques are presented. The course begins with the basics of DC machines and extends to the concept of field orientation in AC machines.

Course Objectives:

- To review the physics of DC and AC machines
- To develop techniques to control the electromagnetic torque of the machine using our understanding of physics
- To compare various forms of control of electric machines
- To provide the student with sufficient background to understand and apply the tremendous wealth of knowledge presented in IEEE publications on this topic
- To provide specific application examples of motors and drives (Robotics, Automation, and Electric Vehicles)

Prerequisites: EE 453 or similar, or consent of instructor (EE 453: Elements of drive systems, speed-torque characteristics of electric motors and industrial loads, solid-state converter. Starting and braking methods of loaded motors. Speed control of electric motors. Solid-state drives. Transient analysis of loaded motors. Special forms of individual- and multimotor drives)

Course Outline:

1. Review of Brush DC Machines
 - Equivalent Circuit
 - Speed/Torque Characteristics
 - Torque Control
2. Extension of Brush DC Machines to Brushless DC Machines
 - Equivalent Circuit
 - Torque Control
3. Basics of Induction Machines
 - Equivalent Circuit
 - Line-Fed Speed/Torque Characteristics
 - V/Hz Control

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4. Induction Machine Modeling/Servo Control
 - Complex Vector Modeling of Induction Machines
 - Field Orientation Control for Induction Machines
5. PM AC Machine Modeling/Servo Control
 - Model of PM Flux Source
 - Extension of Field Oriented Control of PM AC Machines
6. Brief Overview of Motion Control
 - Separation of Motor/Motion Control
 - Basic Motion Control Techniques for Servo Systems

Course Text:

There is no assigned textbook for this course. Technical papers, reports, and notes will be provided to the students. The following books can be used as reference.

- [1] *Introduction to Electric Machines and Drives*, D.W. Novotny, T.A. Lipo, and T. M. Jahns, Wisconsin Power Electronics Research Center, Madison, WI, 2009.
- [2] *Fundamentals of Electric Drives*, Mohamed A. El-Sharkawi, Brooks/Cole, Pacific Grove, Ca, 2000.
- [3] *Vector Control and Dynamics of AC Drives*, D.W. Novotny and T.A. Lipo, Clarendon Press, Oxford, 1996.
- [4] *Brushless Permanent Magnet and Reluctance Motor Drives*, T. J. E. Miller, Magna Physics Publishing, Madison, WI, 1993.
- [5] *The Field Orientation Principle in Control of Induction Motors*, A. M. Trzynadlowski, Kluwer Academic Publishers, Norwell, MA, 1994.
- [6] *Vector Control of AC Machines*, P. Vas, Oxford Science Publications, New York, 1990.