EECS 419   Electric Machinery and Drives
Winter 2018

1. **Prerequisites**: EECS 215 and 216, or graduate standing

2. **Lecture Times:** Tuesdays & Thursdays 10:30am-12:00pm, 1003 EECS

   Lab Times: Wednesdays 3pm-6pm and Fridays 3pm-6pm, 3437 EECS

3. **Purpose:** In the struggle to address today's energy and environmental challenges, many potential solutions require electro-mechanical energy conversion. Examples include electric propulsion drives for electric and hybrid electric vehicles, generators for wind turbines, and high-speed motor/alternators for flywheel energy storage systems. Each of these systems contains: an electric machine operating either as a motor, a generator, or both; a power electronic circuit which interfaces the machine to a power supply or an electrical system; and a controller which measures electrical and mechanical quantities and uses this information to control the power electronic circuitry. In this course we will cover fundamental electromechanical, power electronic, and control theory in the context of electric drive systems. The capabilities and limitations of different types of electric machines (e.g., permanent magnet, induction) in various drive applications will be covered. MATLAB® Simulink® models will be used throughout the course to give students exposure to the dynamic behavior of these systems. A lab will be held with the class where the students will obtain hands-on experience with electric machines and drives.

4. **Course Outcomes:** Upon successful completion of this course, the student should possess the ability to:

   1. Calculate the electromechanical force or torque generated by a magnetic-field-based device whose electrical terminal properties are known.
   2. Use Pulse-Width Modulation (PWM) techniques to synthesize the desired output voltage from a half-bridge, full-bridge, or three-phase inverter.
   3. Analyze the steady-state behavior of a DC electric machine.
   4. Design a control algorithm that regulates the torque or angular rotor position of a DC electric machine.
   5. Estimate the maximum power output of a DC electric machine as a function of rotor speed.
   6. Analyze the steady-state behavior of a surface-mount permanent magnet AC electric machine in the rotor reference frame.
   7. Design a field-oriented control algorithm that regulates the torque or angular rotor position of a surface-mount permanent magnet AC electric machine
   8. Estimate the maximum power output of a surface-mount permanent magnet AC electric machine as a function of rotor speed.
   9. Analyze the steady-state behavior of an AC induction machine in the stator flux-linkage and rotor flux-linkage reference frames.

10. Design a field-oriented control algorithm that regulates the torque or angular rotor position of an AC induction machine.
11. Estimate the maximum power output of an AC induction machine as a function of rotor speed.

5. Topics

Overview of electric machines and drives
Review of basic circuits and systems theory
Fundamentals of electromechanical devices
    Flux linkage/current relationships
    Energy, co-energy
    Calculation of forces and torques
Fundamentals of power electronics
    Switching elements
    Pulse-Width-Modulation
	Fundamentals of control theory
	    Feedback
	    Feedforward
	DC machines
	Surface-mount permanent magnet AC machines
	Induction AC machines
	Synchronous Reluctance Machines
	Interior Permanent Magnet Machines

6. Required Text: None. Prof. Hofmann is currently writing a textbook for this course. Chapters of the draft manuscript will be handed out to students throughout the semester.

Suggested Texts:

T. Lipo and D. Novotny. *Vector Control and Dynamics of AC Drives.* Oxford, 1996.

R. Krishnan. Electric Motor Drives: Modeling, Analysis, and Control. Prentice Hall, 2001.

N. Mohan. *Electric Drives: An Integrative Approach.* MNPERE, 2001.

7. Course Instructor:

Prof. Heath Hofmann
4421 EECS
(734) 647-1107
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Office hours:
Tuesdays, 1pm-3pm and Wednesdays, 9-11am

Lab Instructors:

Akshay Sarin
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Office hours: TBD

8. Exams: The class will have one in-class midterm exam whose time has yet to be determined. Students will be given at least two weeks' notice as to the midterm date. The final exam will be held on **Monday, April 23rd from 4pm-6pm**. If you have a valid reason for missing an exam, you must notify the instructor at least one week in advance so that a conflict exam can be prepared. Exams are closed-book, but each student is allowed one 8.5" by 11" note sheet for the midterm, and two such sheets for the final. Calculators may be used, but devices with wireless communication may not. Obviously, the answers on a student's exam must be their own work and not that of others. Any student caught cheating on an exam will receive a grade of **0** for the exam. Additional sanctions may also be pursued, following university and college guidelines.

9. Homeworks: Homeworks will be assigned on a chapter-to-chapter basis. Each homework will have approximately six to eight problems. In addition to conventional analytical problems, most homework assignments will also require the student to develop and model a system using Simulink®. An interesting and useful set of Simulink tutorials have been developed by Mathworks and various universities, and can be found at

https://www.mathworks.com/academia/student_center/tutorials/sltutorial_launchpad.html?s_tid=ac_sim_tut_til

Students are encouraged to discuss homework problems in groups. **However, each student must submit their own work.** Students submitting identical work will receive a grade of zero for the homework set. Unless otherwise noted, homework sets are posted on the CTOOLs web site and are due one week later in class. Graded homework sets and homework solutions will be disseminated in class. **Late homework will not be accepted.** Your lowest homework score will be dropped in calculating your overall homework grade. However, in order to perform well on the exams, it is important that you work each homework problem assigned. Although your final homework grade may be unaffected if you do not turn in one of the problem sets, your exam grades, which play a much larger role in determining your final grade, will most likely be adversely affected.

10. Labs: In addition to the lectures, labs will be held where the students will obtain hands-on experience with electric machines and drives. Students will submit a lab report for each lab. In addition to including the data obtained during the lab, lab reports must be well-written and clearly explain the concepts presented during the lab. Measured results will be compared to expected values, with any discrepancies clearly discussed.

11. Grading: The following weighting factors determine your total course score:

Homework	**25%**
Lab Reports	**25%**
Midterm	**25%**
Final	**25%**

The class average does not determine the cutoff points for letter grades (i.e., grades will not be curved). Instead, the cutoff points reflect the technical competencies required of an electrical engineer. The following scale determines your final course grade:

A+	96%-100%	B+	86%-90%	C+	76%-80%	D+	66%-70%	E	<60%
A	93%-96%	B	83%-86%	C	73%-76%	D	63%-66%		
A-	90%-93%	B-	80%-83%	C-	70%-73%	D-	60%-63%		

At the discretion of the instructor, the minimum score needed to earn a certain letter grade may be lowered, but it will not be raised.

12. Web Page: Problems sets and other important files and announcements will be posted on the EECS 419 Canvas site.

13. Attendance: Although attendance will not be taken, you are expected to attend lecture. It is a student's responsibility to acquire handouts and information disseminated in class. In order to encourage attendance, many handouts provided in class, such as book chapters and problem set solutions, will (intentionally) not be available on Canvas.

14. Honor Code: Students in the College of Engineering at the University of Michigan are expected to be intimately familiar with its Honor Code. Details of the Honor Code are available online at:

http://www.engin.umich.edu/students/honorcode/code