Electrical Engineering 575: Analysis of Electric Machines and Motor Drives

Course Description: 3 cr. G. Reference frame analysis, computer simulation, permanent magnet synchronous machines, induction machines, power electronic inverters, pulsewidth modulation, vector control. Prereq: eleceng 330(p), 362(p).


Prerequisites by Topics:
- Three phase power system analysis
- Phasor math
- AC Synchronous motors
- DC motors
- Induction motors
- Basic operation of switching power converters: thyristor-based, buck dc-dc converter, inverter

Course Learning Objectives:
- Students will learn and basic principles of electromagnetic torque production and control
- Students will learn the dynamic torque behaviors of various loads, including affinity law loads, fixed torque loads, viscous loads
- Students will learn the differences of control for DC motors, synchronous AC machines, brushless DC and induction motors
- Students will learn the principles of power conversion and control applied to motor drives
- Students will learn and apply continuous control principles to motor speed and torque control
- Students will learn dq transformations and specific formulations of park’s and clark’s equations and their application to synchronous AC machine and induction motor control
- Students will learn and apply constant volts per Hertz control principles to DC motors
- Students will be able to perform simulations of electric drive systems using either MATLAB-SIMULINK, PLECS or LT-SPICE.

Topics Covered:
- Motor and drive types
- Load types
- Thyristor-based motor controllers
- IGBT-based motor controllers
- Components of a motor drive
- Four quadrant control of motors
- Regenerative braking
- PI torque and speed control of a DC motor
- Brushless DC motors
- Field oriented control of synchronous AC motors
- Field oriented control of induction motors
- Constant volts per Hz control of induction motors

Class: 42 lectures, 2 mid-terms, final, a final class project.
**Test Policy:**
- Tests are closed book.
- Two 8.5 x 11” pages of notes are allowed (both sides of each page)
- Laptops and phones with internet connections are not allowed to be used during tests
- Per university policy, leaving the room during the test should only occur under an emergency situation.
- A calculator is required for tests. Calculators that perform phasor math are allowed and encouraged—but not necessary.
- Exams will cover the material from homework assignments, textbook examples and laboratory exercise.
- Please do not expect to see exact replications of homework problems on exams. I test to see if the concepts are understood. Typically, this means an application of the concept learned or studied to something practical. I purposely do not weight the homework examinations so much that they drastically affect a student’s grade (i.e. you can do poorly on one exam and still pull off an ‘A’ if you do all of the laboratory assignments, homework, etc.) Performing the examination is intended to be part of the learning process. Try to not stress out excessively over the exam and if you do poorly then learn from your mistakes and move on to do better on the next exam
- I purposely change up exam problems every semester. It is unlikely that you will ever see exact replications of an exam problem from prior semesters.

**In-Class Expectations:**
- Attendance at all lectures is very important. If you skip lectures you will likely be lost during subsequent lectures because we move across a very wide range of material in a short time period
- This is not a community college class. Therefore, you will be taught the source of the formulas you are using and expected to pull out of the lecture experience the insights you need to do well in the class and use what you have learned in the class throughout your career. Don’t expect to just to get the formulas so you can plug in answers. The main intent is to learn to apply formulas and derive them if necessary—very important career skills for any engineer
- Because of the nature of my research I have to travel quite a bit. So expect there to be substitute instructors sometimes for a 1 to 2-week stretch.
- I do not tolerate harassment of any kind—particularly towards fellow students.
- I do not tolerate the use of profanity in class

**Homework Policy:**
- Homework problem sets are posted on D2L
- Students will have 2 weeks to complete homework assignments on average
- The content of the homework will be covered in class up to one lecture period before the homework is due—therefore it is important to begin the homework as soon as it is posted and to attempt homework problems as the content is explained in class concurrently. In some cases, it may be necessary for the student to look at the material ahead of coverage in class (i.e. through textbook examples).
- It is the responsibility of the student to exercise whatever means necessary to understand the content of the class. The class lectures are one resource. The textbook is another resource.
- Attempts are made to change up the homework problems each semester. In some cases, homework problems may be repeated from semester to semester. If at any time it is obvious that a student has simply copied a prior homework assignment, then the instructor will schedule a meeting with that student and give them a chance
to rectify the situation by re-doing the homework. If the student takes no action, then that student can expect to receive 0% credit for the copied homework problem.

- Homework assignments are turned in at the beginning of class on the due date unless the instructor states otherwise.
- Homework solutions are posted on D2L after the due date. If a homework is turned in late, the student will not receive full credit.
- In some cases, the instructor may post solutions prior to the homework due date. If this occurs the instructor will give 100% credit to all homework assignments that are turned in by the due date for each problem that is attempted.

**Final Project**
The final project will be a team effort, involving 2-3 people. The final project is graded based upon an in-class presentation by all team members. There is no guarantee that all members of the same team will receive the same grade. Contribution of students to the project will be judged based upon their parts in the final presentation. It is therefore important for each student to present their contributions to the project. Grades are based upon the individual’s insights, efforts and passion for the project. The project presentations will occur the last two class periods.

**Potential Projects:**
- Regenerative braking review or new topology
- Design and Simulation of High Performance DC Motor Controls
- Sensorless Controls
- New topologies or control methods for BLDC drives
- Reduced part topologies
- EMI sources and reduction methods in different drives e.g. DC, induction
- high temperature AC synchronous superconducting motor
- Application of motor drives in electric, hybrid, and fuel cell vehicles
- Multi level converter drives
- Analyze and simulate a drive circuit for induction, BLDC, or SRM
- Simulate Direct or Indirect Field Oriented Control of Induction Machine

**Investment of Time by Student:**
The average student should expect to spend 10 hours per week on this class, that includes in-class lecture and lab time. Time expectation is broken down as follows (in hours over the total span of the semester):

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Class Lectures</td>
<td>31.25</td>
</tr>
<tr>
<td>Lecture Note Study Time</td>
<td>12.5</td>
</tr>
<tr>
<td>Time spent on Homework</td>
<td>48</td>
</tr>
<tr>
<td>In-Class Exam Time</td>
<td>4.5</td>
</tr>
<tr>
<td>Exam Study Time</td>
<td>36</td>
</tr>
<tr>
<td>Project Presentation Time</td>
<td>10.5</td>
</tr>
<tr>
<td>Project Preparation Time</td>
<td>30</td>
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</tbody>
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**Grading Break-Out:**
- Mid-Term Exam: 20%
- Homework: 20%
- Term Project: 30%
- Final Exam: 30%
Academic Misconduct:
Academic misconduct is an act in which a student seeks to claim credit for the work or efforts of another without authorization or citation, uses unauthorized materials or fabricated data in any academic exercise, forges or falsifies academic documents or records, intentionally impedes or damages the academic work of others, engages in conduct aimed at making false representation of a student’s academic performance, or assists other students in any of these acts.

Prohibited conduct includes cheating on an examination; collaborating with others in work to be presented, contrary to the stated rules of the course; submitting a paper or assignment as one’s own work when a part or all of the paper or assignment is the work of another; submitting a paper or assignment that contains ideas or research of others without appropriately identifying the sources of those ideas; stealing examinations or course materials; submitting, if contrary to the rules of a course, work previously presented in another course; tampering with the laboratory experiment or computer program of another student; knowingly and intentionally assisting another student in any of the above, including assistance in an arrangement whereby any work, classroom performance, examination or other activity is submitted or performed by a person other than the student under whose name the work is submitted or performed.

An instructor who believes a student has engaged in academic misconduct first discusses the matter with the student. Following the meeting, if the instructor concludes that misconduct occurred, the instructor may impose a sanction of reprimand, a repeat assignment, lower or failing grades for the assignment or course, or removal from the course. All sanctions may be appealed to a hearing committee.

An instructor who considers the misconduct to be serious enough to warrant probation, suspension or expulsion makes such a recommendation to the appropriate investigating officer (IO) who is an appointee of the dean in the student's school or college. If after discussions with the student the IO agrees with the instructor’s recommendation, a hearing is scheduled before the academic misconduct hearing committee corresponding to the students status (undergraduate or graduate). Relative to such hearings students have a right to a written notice of the alleged offense and sanction sought, to question adverse witnesses, to be heard and present evidence, to be represented and obtain a record of the hearing at student expense and to a written decision and a copy of all applicable procedures. Students who are suspended or expelled by a hearing committee may appeal to the Chancellor.

Suspensions and expulsions bar enrollment at any campus in the UW System. Students may petition for readmission after half of the suspension period, in the case of suspensions, or one year in the case of expulsions.

Records of all disciplinary actions are maintained by the Dean of Students.

Contribution of Course to Meeting the Professional Component of ABET Accreditation:
This course contributes to the engineering sciences component of the curriculum. Students learn fundamental electrical engineering science concepts related to electric machinery and power systems.