University of New South Wales  
School of Electrical Engineering & Telecommunications  

ELEC4613 - ELECTRIC DRIVE SYSTEMS  

Course Outline for S2, 2010

**Brief Syllabus:**

Elements of drive systems; requirements of industrial drives. Drive representation, quadrant operation, dynamic and regenerative braking. DC motors, converters for DC motor drives, drive performance analysis. Performance analysis of synchronous motor drives with variable or current source and variable frequency supply. Performance analysis of induction motor drives with variable voltage or current source and variable frequency supply. Field oriented (or vector) control of induction motor drives; Computer aided design.

**Course Webpage:**

All lecture notes, assignments, tutorial and laboratory sheets for this subject can be found on the school webpage, via Current Students → Study Notes → Lecture Notes. You may have to enter username: *(your student number)* and password: *eed&view*. Students will be expected to bring the printed lecture notes, tutorial or laboratory sheets into the lecture/tutorial room or laboratory, as appropriate. They are also expected to visit this site regularly to keep up-to-date on Lecture Notes, Tutorial and Laboratory sheets, announcement of mid-session test and other announcements information related to this course.

**Lecture Content/Schedule**

There will be three hours of lecture per week. The total number of lecture hours over the 12-week session will about 30, the remaining 6 hours will comprise of problem solving/tutorial/computer modelling sessions in lieu of formal lectures. The third hour of lecture in even weeks will be used for these sessions. Lecture notes are available from the course Lecture Notes webpage.

<table>
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<tr>
<th>Course Content</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1. Introduction to Electrical Drives</td>
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<tr>
<td>Rotational Systems, Load couplings, representation of torque referred to motor and load shafts; Energy relationship. Quadrant operation Steady-state and dynamic operation</td>
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<td>2. DC motor drives</td>
<td>5</td>
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3. **Brushless DC drives**

BLDC machine fundamentals; Analysis of machine back emf and torque; Ideal back-emf and current waveforms, Sensor requirements

4. **Synchronous motor drives**

Review of synchronous motors and characteristics
Salient and non-salient pole machines; Reluctance motors
Performance under Voltage Source Inverter (VSI) drive
Performance under Current Source Inverter (CSI) drive
Operation with maximum torque, field-weakening and Unity power factor.

5. **Induction motor drives**

Drive characteristics using equivalent circuit representation
Parameter determination of induction machines
Voltage and current source drives
Characteristics with VSI-VF inverter and CSI-VF drive
Static Scherbius drive
Effect of harmonics on drive performance

6. **Machine representation in orthogonal axes**

Representation of machine dynamics; Stator, synchronous Rotor reference frames. General orthogonal set;
representation of AC machines in orthogonal reference frames. Representation of synchronous machine dynamics in the stator and rotor reference frames; d- and q-axes currents and fluxes;
the developed torque and rotor flux oriented control (RFOC).

Representation of induction machine dynamics in the stator and synchronously rotating reference frame; Condition for alignment of the direct-axis with rotor-flux axis. Indirect rotor-flux oriented control (RFOC) structure; effect of rotor time-constant on RFOC.

7. **Controller design for electrical drives**

Role of various control loops in drive systems; drive system damping;
torque, speed and position control loops; hierarchy of control loops;
Typical controllers; design considerations for each control loop.

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**Total hours**

30

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**Staff Contact Details**

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<tr>
<th>Position</th>
<th>Name</th>
<th>Email</th>
<th>Availability; times and location</th>
<th>Phone</th>
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<tbody>
<tr>
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<tr>
<td>Tutor</td>
<td>TBA</td>
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Aims of this course

The aim of this course is to equip students with knowledge of variable-speed drives and motion control systems which are used in many industrial processes such as in conveyors, machine tools, pumps, compressors, mining drives, electric vehicles, ship propulsion, wind energy systems, aircraft actuators, servo drives and automation systems, to name a few. The course stresses the basic understanding of characteristic of machines driven from appropriate power electronic converters and controllers. The steady-state behaviour of such drives will be primarily covered and some dynamic issues of drive representation and control system design will also be included.

Student Learning Outcomes and Graduate attributes

At the conclusion of this course, the students will be able to:

1. understand fundamental elements of drive systems, analyse the steady-state characteristics of a few commonly used types of drives used in the industry.
2. understand the performance of these drives supplied from appropriate converters.
3. understand the quadrant operation of various types of drives and their control requirements, selection of converters, components, etc.
4. understand how to design the hierarchical control structures for drive systems.
5. be able to select and design important elements of a drive system.
6. be able to apply the theories of electrical machines, power electronic converters and control system design to implement drive systems which are appropriate for specific performances.

Tutorial

There will be a one-hour tutorial class in even weeks. Tutorial sheets are available on the webpage for this course. Solution of all tutorials will be posted on the course webpage progressively, sometime after the material for each tutorial has been covered in tutorial class. Tutorial classes will start in week 2.

Laboratory

The laboratory for this course consists of four experiments, E1 – E4, which will be conducted in room EE119. There are two laboratory sets for each experiment. A maximum of two students can be accommodated for each set. Laboratory will start in week 2 or 3 for students enrolled in even and odd weeks, respectively. Laboratory sheets are available from the course website.

Students are required to read the School Safety Manual for Laboratory and Laboratory Safety Instructions for Laboratory for this course, and submit the signed Laboratory Safety Declaration form to the lab supervisor when you start your first laboratory experiment.
Quiz/Hand-in-assignment

There will be one Mid-session Test (closed-book) in week 7. It will consist of numerical problem solving and descriptive parts based on material covered up to week 6. Time and location of the test will be announced in due course. This test will be held under normal examination-like conditions. Mark scored in this test (out of 15) should be indicative of the level of understanding of and proficiency in the topics covered prior to the assignment.

Assessment

The final examination at the end of the session will account for 65% of the total marks.

20% of the final mark is allocated to laboratory. The laboratory consists of four laboratory experiments, E1 - E4, which is a compulsory part of this course. Attendance of laboratory, satisfactory performance during lab and submission of a laboratory report will be marked by the laboratory demonstrators at the end of each laboratory. Each lab thus is worth 5 marks.

There will be a mid-session test about half-way through the session, worth 15 marks.

The final score for this course will thus will be:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Laboratory</td>
<td>20%</td>
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<tr>
<td>Mid-session Test</td>
<td>15%</td>
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<tr>
<td>Final examination</td>
<td>65%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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Text Books and References

Lecture notes in PDF format are available via the School webpage for Lecture Notes. The following books may be consulted for further reading: