ECE 314 Syllabus, Fall 2014

Course website: https://portal.utoronto.ca/

Course Description

This course is intended to provide students with an understanding of the principles of operation, modeling, and analysis of electric energy conversion devices (a more detailed list of learning objectives is provided at the end of this document). This course primarily relies on linear circuit analysis concepts (ECE 159 or equivalent).

Course Texts

Two texts have been assigned for this course:

- Course packet for ECE 314 & ECE 349, available from Alicos (next to Starbucks on College), consisting of the following textbook excerpts:
  - P. Krein, Elements of Power Electronics, Oxford Press, 1998, Chapter 6 and Appendix A.

Meeting Times

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<th>Tutorials</th>
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<td>Wed 13:10-14:00 GB248</td>
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Lab Schedule

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<td>PRA 06</td>
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Course Outline

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<td>Analysis of dc/dc converters</td>
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<td>Switch realization and switching losses</td>
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<td>Continuous/discontinuous conduction mode boundary</td>
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<tr>
<td>Analysis of periodic signals (Fourier series, rms, power factor, distortion)</td>
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<td>Erickson: §16.1-16.3</td>
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<tr>
<td>Dc/ac conversion (square wave, PWM)</td>
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<td>Krein: §6.1-6.4</td>
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<td>Magnetic circuits, inductance, magnetic materials</td>
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<td>Fitzgerald: §1.1-1.5</td>
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<td>Fitzgerald: §2.1-2.6</td>
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<td>Electromechanical energy conversion</td>
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<td>Fitzgerald: §3.1-3.6, 3.8, 4.1-4.2, 4.4, 5.1-5.2</td>
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</table>
Homework
Homework will be assigned (roughly) every other week to reinforce material covered in lectures. Homework must be turned in to the ECE314 box on the first floor of Sandford Fleming (south hallway, just past the doors connecting SF and GB). Late submissions of homework will incur a 20% penalty per day, rounded up.

Academic offences
Homework assignments are to be completed and handed in individually. Academic offences will be handled according to faculty policy (see the Academic Regulations section of the Faculty of Applied Science and Engineering Calendar).

Tutorials
There is a weekly tutorial for this course and it will be used to answer questions about homework assignments and expand on the lecture materials.

Midterm
There will be one two-hour midterm, worth 30% of the total course mark, on October 22 from 6pm to 8pm. This test will be closed-book and closed-notes, but you will be given an equation sheet (which will be posted to the course website in advance).

Calculators
For the midterm and final examination, you are allowed to use a non-programmable calculator.

Excused absences
If you are unavoidably absent at any time before the end of lectures, declare your absence on ROSI and discuss the absence with me as soon as possible. In all cases, you must submit a Petition Form for Term Work to me, along with any relevant documentation (e.g., a UofT Medical Certificate), within a week of your return to class.

If you are not present for the final examination, alternative procedures must be followed (Faculty Registrar website).

Laboratory
The laboratory sessions will run in the Energy Systems Lab, GB40, and consist of one mandatory introductory session and four lab experiments. A handout for each lab will be posted in advance on the course website.

All labs (except for the Introductory Lab) include a graded lab prep. In the interest of fairness, all lab preps for all students must be turned in before the first section of that lab meets. For example, the first section of the dc/dc conversion lab is on October 6, at 9am (PRA 06). That means the lab prep for the dc/dc conversion lab is due for everyone at 9am on October 6. Late submissions of the lab prep will incur a 20% penalty per day (rounded up). If you are in the first section (e.g., PRA 06 for the dc/dc conversion lab), turn in your lab prep at the beginning of the lab. If you are in any other section, turn in your lab prep to the ECE314 box on the first floor of SF.

Final Examination Details
Examination Type: C (single aid sheet is allowed)
Calculator: Non-programmable

Composition of Course Mark
Final Examination: 45%
Midterm: 30%
Homework: 10%
Laboratory: 15%

Contact Details
Email: zeb.tate@utoronto.ca
Website: http://www.ele.utoronto.ca/~zeb/
Office: SF 1021G
Office hours: Wednesdays, 12:10-1:00PM (or by appointment)
Learning Objectives

Power Electronics

• Explain the economic and performance advantages of switching power converters
• Evaluate arbitrary switching converter topologies; using the concepts of volt-second balance, charge balance, and small ripple approximation; to determine their steady-state behavior
• Estimate the current and voltage waveforms within a converter and make design decisions based on specifications
• Develop steady-state models of converter operation, incorporating non-idealities in passive and active components
• Identify voltage and current blocking requirements for a given topology and select the appropriate physical switching devices
• Derive operating limits to ensure a converter remains in the desired operating mode (e.g., continuous conduction mode)
• Compute the Fourier series coefficients, rms value, power factor, and total harmonic distortion of periodic signals
• Apply superposition to determine the behavior of circuits subject to distorted, periodic current and voltage signals
• Understand common approaches used for dc-ac conversion (modified square wave, pulse width modulation) and their relative benefits
• Explain how dc-ac converters are controlled to achieve bidirectional complex power transfer with a power grid

Magnetics

• Derive and solve a magnetic circuit—given a physical geometry, electrical connections, and material properties—to determine the relations between current and flux in a magnetic system
• Apply Faraday's Law to determine the inductance of a system with a given geometry and (single or multiple) winding configuration
• Design an inductor that meets desired specifications
• Apply the dot marking convention to designate winding terminals in multi-winding systems
• Explain what is meant by magnetic saturation and hysteresis
• Explain why some materials are known as permanent magnets
• Derive the fundamental relations of an ideal ac transformer using Ampere's and Gauss' Law
• Identify limitations in ideal transformer model
• Develop equivalent circuit models of non-ideal transformers and estimate the parameters of these circuit models using open- and short-circuit transformer tests
• Explain how saturation and hysteresis affect transformer distortion and efficiency

Electromechanics

• Using the Lorentz Force Law, determine the force on a current-carrying conductor in a magnetic field
• Using the co-energy approach, derive expressions for the forces and torques in linear and rotational electromechanical systems
• Identify limitations of the co-energy approach
• Derive models of linear and rotational electromechanical systems that capture both steady-state and dynamic electrical and mechanical behavior
• Distinguish between stable and unstable equilibria of an electromechanical system
• Based on the physical layout, determine general sinusoidal expressions for the self- and mutual inductance of a rotational electromechanical system
• Explain how a reluctance machine operates and derive expressions for torque as a function of rotor position
• Explain why synchronous machines are called synchronous machines and the basic principles governing their operation
• Using the equivalent circuit of a synchronous machine, determine the maximum average output that can be achieved
• Using the equivalent circuit of a synchronous machine, determine the field current so that certain specifications (e.g., unity power factor operation) are met