Course Outline

**ELE806: Alternative Energy Systems**

**Prerequisites**
- ELE754 Power Electronics and ELE847 Advanced Electromagnetic Systems (W2015)
- ELE747 Advanced Power Electronics (Starting W2016)

**Course Type:** Compulsory for Energy Option  
**Program Level:** ELCE 08 (8th Semester)  
**Website:** N/A

**Compulsory Texts:**
2. ELE806 Course Notes: Available on Blackboard
3. ELE806 Laboratory Manuals: Available on Blackboard

**Reference Texts:** None

**Calendar Description**
A course on modeling, analysis and design of wind and solar energy systems. The main topics include: overview of wind energy conversion systems (WECS), wind generators and modeling, power converters in renewable energy systems, fixed- and variable-speed induction generator WECS, synchronous generator based wind energy systems, doubly fed induction generator (DFIG) WECS, photovoltaic (PV) power conversion systems, and introduction to tidal and wave energy systems. Important concepts are illustrated by case studies and are further investigated in the laboratory.

**Learning Objectives**
At the end of this course, the successful student will be able to:

1. Use specialized core knowledge of power electronics, electric machines and control theory to understand and design 1) a wind energy conversion system using squirrel cage induction generator, doubly-fed induction generator, or synchronous generator, and 2) a photovoltaic (PV) energy conversion system with maximum power tracking control (1d)
   
   a. **Assessment Methods**: Directly assessed through midterm and final examinations, and laboratory reports.

   b. **Assessment Measures**: Marks obtained from midterm and final examinations, and laboratory reports.

2. Generate solutions for the design of PWM switching schemes, grid-side power factor compensation, PI compensator, maximum power point tracking, and control schemes
for various wind and solar energy systems with a give set of design requirements (4d)

a. **Assessment Methods**: Directly assessed through midterm and final examinations, and laboratory reports.

b. **Assessment Measures**: Marks obtained from midterm and final examinations, and laboratory reports.

3. Use of Matlab/Simulink tool extensively to investigate and solve complex problems in wind and solar energy systems, including analysis and modeling of fixed- and variable-speed wind energy systems and solar energy systems with partial shading problems (5c).

a. **Assessment Methods**: Assessed through laboratory sessions and reports.

b. **Assessment Measures**: laboratory performance and marks earned from laboratory reports.

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**Course Organization**

<table>
<thead>
<tr>
<th>Course</th>
<th>3 hours of lecture per week for 13 weeks for all sections</th>
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<tbody>
<tr>
<td>Organization</td>
<td>1 hour of lab per week for 12 weeks</td>
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<tr>
<td></td>
<td>3 to 4 lab sections of maximum 20 students each</td>
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<td>2 Teaching Assistants (TA), 2 sections per TA</td>
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**Course Evaluation**

| Midterm Exam | 25% |
| Laboratories | 30% |
| Final Exam | 45% |
| Total | 100% |

To achieve a passing grade, student must pass both the theory and laboratory components.

**Examinations**

Midterm Exam in Week 7, 2 hours, closed book with a formula sheet (covers Weeks 1-6 of lecture and laboratory material).

Final Exam, during exam period, 2 hours, closed book with a formula sheet (covers Weeks 7-13 of lecture and all laboratory material).

**Course Contents**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Sections</th>
<th>Hours</th>
<th>Detailed Description</th>
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<tbody>
<tr>
<td>1. Introduction</td>
<td>All</td>
<td>2</td>
<td>State-of-the-art wind energy systems, wind turbine technology, wind energy conversion, fixed-speed and variable-speed wind energy systems, grid codes, power factor compensation. (Chapter 1, textbook)</td>
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<tr>
<td>2. Fundamentals of Wind Energy Conversion Systems (WECS)</td>
<td>All</td>
<td>2</td>
<td>Wind turbine components, turbine power characteristics, turbine modeling, passive and active stall controls, pitch control, tip speed ratio, maximum power point tracking schemes. (Chapter 2, textbook)</td>
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<tr>
<td>3. Wind Generators and Modeling</td>
<td>All</td>
<td>4</td>
<td>Reference frame transformation, induction generators (IG), IG dynamic and steady state models, synchronous generators (SG), SG</td>
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<tr>
<td>Week</td>
<td>Title</td>
<td>Details</td>
<td>Time</td>
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| 2,3  | Lab 1 - Modeling and Simulation of Fixed-Speed Wind Turbines | - Implement the fixed-speed wind turbine model for induction generator based WECS,  
- Study the power and torque curves for wind turbine, and  
- Investigate the pitch angle control system. | 2 hrs |
| 4,5  | Lab 2 - Modeling and Simulation of Induction Generators | - Implement the squirrel-cage induction generator (SCIG) in arbitrary reference frame,  
- Investigate the dynamic response of SCIG with direct grid connection, and  
- Compare the response of SCIG model with Sim-Power-Systems model. | 2 hrs |
| 6,7  | Lab 3 - Decoupled Voltage Oriented Control of Grid-Tied Inverters | - Understand the principle of VOC with a decoupling controller for grid-tied inverter,  
- Design the sinusoidal pulse width modulation scheme for grid-tied inverter, and  
- Investigate the active and reactive power control with the grid-tied inverter. | 2 hrs |
<table>
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<tr>
<th>Lab</th>
<th>Description</th>
<th>Requirements</th>
<th>Duration</th>
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| 8,9 | Lab 4 - Fixed-Speed Induction Generator based WECS | - Implement the fixed-speed squirrel-cage induction generator based WECS,  
- Investigate the dynamic response of SCIG WECS with direct grid connection and soft start, and  
- Design and implement reactive power compensation scheme for fixed-speed WECS. | 2 hrs |
| 10,11 | Lab 5 - Zero d-axis Current (ZDC) Control of PMSG WECS | - Design the ZDC control for variable-speed, direct-drive non-salient pole PMSG WECS,  
- Design the sinusoidal pulse width modulation scheme for generator-side converter, and  
- Investigate study the dynamic performance of PMSG WECS during start-up. | 2 hrs |
| 12,13 | Lab 6 - Grid-Connected Photovoltaic Power Generation with MPPT Control | - Design PV inverters and control scheme for grid connection,  
- Design and implement maximum power point (MPPT) control, and  
- Optimize the performance of the PV system. | 2 hrs |

**Important Notes**

1. All of the required course-specific written reports will be assessed not only on their technical/academic merit, but also on the communication skills exhibited through these reports.
2. All assignment and lab/tutorial reports must have the standard cover page which can be completed and printed from the Department website at www.ee.ryerson.ca. The cover page must be signed by the student(s) prior to submission of the work. Submissions without the cover pages will not be accepted.
3. Should a student miss a mid-term test or equivalent (e.g. studio or presentation), with appropriate documentation, a make-up will be scheduled as soon as possible in the same semester. Make-ups should cover the same material as the original assessment but need not be of an identical format. Only if it is not possible to schedule such a make-up may the weight of the missed work be placed on the final exam, or another single assessment. This may not cause that exam or assessment to be worth more than 70% of the student’s final grade. If a student misses a scheduled make-up test or exam, the grade may be distributed over other course assessments even if that makes the grade on the final exam worth more than 70% of the final grade in the course.
4. Students who miss a final exam for a verifiable reason and who cannot be given a make-up exam prior to the submission of final course grades, must be given a grade of INC (as outlined in the Grading Promotion and Academic Standing Policy) and a make-up exam (normally within 2 weeks of the beginning of the next semester) that carries the same weight and measures the same knowledge, must be scheduled.
5. Medical or Compassionate documents for the missing of an exam must be submitted within 3 working days of the exam. Students are responsible for notifying the instructor that they will be missing an exam as soon as possible.
6. Requests for accommodation of specific religious or spiritual observance must be presented to the instructor no later than two weeks prior to the conflict in question (in the case of final examinations within two weeks of the release of the examination schedule). In extenuating circumstances this deadline may be extended. If the dates are not known well in advance because they are linked to other conditions, requests should be submitted as soon as possible in advance of the required observance. Given that timely requests will prevent difficulties with arranging constructive accommodations, students are strongly encouraged to notify the instructor of an observance accommodation issue within the first two weeks of classes.
7. The results of the first test or mid-term exam will be returned to students before the deadline to drop an undergraduate course in good Academic Standing.

8. Students are required to adhere to all relevant University policies including:
   Undergraduate Grading, Promotion and Academic Standing, [http://www.ryerson.ca/senate/policies/pol46.pdf](http://www.ryerson.ca/senate/policies/pol46.pdf)
   Student Code of Academic Conduct, [http://www.ryerson.ca/senate/policies/pol60.pdf](http://www.ryerson.ca/senate/policies/pol60.pdf)
   Undergraduate Academic Consideration and Appeals, [http://www.ryerson.ca/senate/policies/pol134.pdf](http://www.ryerson.ca/senate/policies/pol134.pdf)

9. Students are required to obtain and maintain a Ryerson Matrix e-mail account for timely communications between the instructor and the students.

10. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented.

11. In-class use of cellular telephones is not permitted. Please turn off your cell phone prior to class. Quiet use of laptops, text-messengers and similar non-audible devices are permitted only in the rear rows of the class. This restriction allows use of such devices by their users while limiting audible and visual distractions to other students. This policy may change without notice.

12. Labs, projects handed in past the due date and time will not be accepted for marking and will receive a mark of zero. In some genuine cases late submission will be allowed with a penalty of 5% per day.

13. Students found to have plagiarized any portion of their labs and final project will receive a grade of zero on the complete project. This automatically will lead to a failing grade.

   Course Coordinator __________________________                Date ________________________________

   Approved by ____________________________                Date ________________________________

   Program Director
   or Department Chair