WESTERN UNIVERSITY

FACULTY OF ENGINEERING DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE 9406-9046/L-Power Electronics for Industrial Applications

COURSE OUTLINE-Summer 2018

Description: The use of power electronics in industrial applications has grown in recent years. Applications such as renewable energy systems, electric vehicles, and utility power require power electronic converters that can convert power from available sources into power demanded by loads, or that can control the flow and the nature of power in a system. This course will focus on the use of power electronics in certain industrial applications and will emphasize modelling and control strategies of power converters used in these applications. There will be two parts to this course: In the first part, several widely used power electronic converter topologies will be reviewed and their modeling and control will be explained. In the second part, examples of industrial applications where power electronics is used will be discussed. These applications will include solar photovoltaic (PV) and wind energy harvesting systems, electrical and plug-in electrical vehicles (EV and PHEV) and their integration into the power grid, and power converters in active distribution power system networks.

Contact Hours: 3 lecture hours per week. (Half course)

Prerequisites: There are no prerequisites for this course, but ECE 9043A, ECE 4457A and ECE 3330A or equivalents are recommended.

Learning Outcomes:

The following are learning outcomes for this course:

DC/DC converter control: By the end of this section, the student will be able to analyze, model, and design control systems for basic DC/DC converters, that can be used for PV energy conversion and EV systems, etc.

Three phase converter control: By the end of this section, the student will be able to analyze configurations and modulation techniques that are used in basic three phase AC/DC or DC/AC converters and develop dynamic models for them. The control of AC/DC or DC/AC three phase converters will also be studied in this section. These converters can be used for application such as PHEV integration to grid, PV and wind energy conversion systems, etc.

Single phase converter control: By the end of this section, the student will be able to analyze configurations and modulation techniques that are used in basic three phase AC/DC or DC/AC converters and develop dynamic models for them. The control of AC/DC or DC/AC single phase converters will also be studied in this section. These converters can be used for application such as PHEV integration to grid, active power distribution network control, etc.

Photovoltaic energy conversion: By the end of this section, the student will be able to analyze the PV energy conversion system components at the system level and use the abovementioned power electronic converters to design the PV energy conversion system.

Wind energy conversion: By the end of this section, the student will be able to analyze the wind energy conversion system components at the system level and use the abovementioned power electronic converters to design the wind energy conversion system.

Electric and plug-in hybrid electric vehicles (EV and PHEV): By the end of this section, the student will be able to analyze the electrical system of the EV and PHEV and power electronic converters that are used in the EV and PHEV and their charging infrastructure.

Active distribution networks: By the end of this section, the student will be able to define the concepts of active distribution networks and its control hierarchy, and potential applications of the power electronic converters in the active distribution networks.

Course Outline:

1. Theory:

1.1. DC/DC converters modelling and control

Review of basic DC/DC converters topologies

Development of dynamic model for DC/DC converters

Control system design for DC/DC converters

1.2. Three phase converters modelling and control

Review of basic three phase converter topologies

Development of dynamic model for three phase converters.

Modulation techniques

Control system design for converter control.

1.3. Single phase converters modelling and control

Review of basic single-phase converter topologies

Development of dynamic model for single phase converters

Control system design for converter control

2. Applications:

2.1. Photovoltaic (PV) solar energy conversion

Basics of PV solar systems

Grid-connected PV systems

2.2. Wind energy conversion

Basic principles of generators that are used in wind power conversion systems

Back to back converters (AC-DC-AC)

2.3. Electric and Plug-In Hybrid Electric vehicles

HEV and PHEV Topologies.

Power electronic converters for charging (regular and wireless)

Concepts related to vehicle-to-grid (V2G) and vehicle-to-home (V2H) systems

2.4. Active distribution networks (ADN) for power systems

ADN architecture

ADN control hierarchy

Power electronic converters in ADN

Textbook:

There is no compulsory textbook for the course. Course notes will be provided on the OWL website.

Recommended References:

1. R. Erickson; D. Maksimovic, *Fundamentals of Power Electronics*, 2nd ed. Springer US, 2001.
2. S. Chakraborty; M. G. Simões; W. E. Kramer, *Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration,* Springer, 2013
3. S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles,* Springer, 2013
4. S. Chowdhury, P. Crossley, *Microgrids and Active Distribution Networks,* Institution of Engineering and Technology, 2009

Evaluation

The final course grades will be comprised of the four following components:

Course Component	Weight
Assignments	20%
Project	30%
Midterm exam	20%
Final exam	30%

Assignments:

There will be around 3 assignments for this course. Each assignment will combine analysis and computer simulation related to the material presented in class or online.

Project:

Each student will be assigned a course project. The project will consist of the modelling, design and simulation of a power electronic system that is used in an industrial application. The deadline for the project report submission will be 7 days before the date of the final exam.

Examination:

Only the use of non-programmable calculators will be allowed for the final examination. No other aids will be allowed unless specified.

Use of English:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work except for the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Absence Due to Illness or Other Circumstances:

Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal. For more information concerning medical accommodations, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf
For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Missed Midterm Examinations:

If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test. If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

Cheating and Plagiarism:

Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.
All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).
Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Use of Electronic Devices:

Students may use laptops, tablet computers, or smart phones only to access the course website during lectures and tutorials. No other electronic devices may be used at any time during tests or examinations.

Policy on Repeating All Components of a Course

Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

Internet and Electronic Mail:

Students are responsible for regularly checking their Western e-mail and the course web site: http://essex.cc/teaching/Information-Security/ (or essex.cc/security for short) and making themselves aware of any information that is posted about the course.

Accessibility:

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services:

Office of the Registrar, http://www.registrar.uwo.ca/
Student Development Centre, http://www.sdc.uwo.ca/

Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/
USC Student Support Services, http://westernusc.ca/services/
Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help