DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE 9408A (Ph.D., M.ESc.), ECE 9048A (M.Eng.)

Modeling Power Systems for Protection, Control, and Transients Studies

COURSE OUTLINE – Fall 2018

Description:

This course provides the students with theoretical and practical knowledge of Power Systems modeling and time-domain simulation. The aforementioned knowledge has significant applications in many areas including Power Systems Protection, Control, and Transients.

Instructor: Dr. Firouz Badrkhani Ajaei
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Consultation hours: By appointment

Specific Learning Objectives:

Upon completion of this course, the students should be able to:

■ describe the principles/advantages/limitations/applications of power systems simulation using electromagnetic transients programs, e.g., PSCAD and EMTP;

■ choose the appropriate modeling strategy for each specific application;

■ develop models in PSCAD/EMTDC program, based on their needs;

■ effectively use the developed models for numerical analysis, i.e., time-domain simulation.

Contact Hours:
3 lecture hours, 2 laboratory hours

Antirequisites:
None

Prerequisites:
ECE 4464A or equivalent

Course Content:

1. Principles of Modeling and Simulation
- Introduction to time-domain simulation
- Applications, advantages, and limitations of off-line time-domain simulation
- Modeling linear and nonlinear components
- Circuit discretization, integration methods, and numerical stability
- Choosing a proper simulation time-step

2. Loads
- Static and dynamic loads
- Induction motors

3. Generation Systems
- Synchronous generator, excitation systems, prime movers
- Wind turbine-generators
- Photovoltaic Generation Systems

4. Transmission Lines
- Distributed and lumped models of over-head lines and cables in AC and DC systems
- Frequency dependence of line parameters
- Electromagnetic wave propagation

5. Transformers
- Linear transformer models
- Non-linear characteristics of transformers and inductors (hysteresis, saturation, transformer inrush current, etc.)
- Grounding transformers
- Current Transformers (CT)
- Potential Transformers (PT) and Capacitive Voltage Transformers (CVT)

6. Over-voltages and Surge Arresters
- Causes and characteristics of over-voltages
- Surge arrester nonlinear characteristic and energy handling capability

7. Power Electronics
- Power semiconductor devices
- Power converters
- Line Commutated Converters (LCC)
- Voltage Sourced Converters (VSC)

Textbook:
There is no required textbook for the course. Course notes will be provided on the course website. Additional supplementary material, e.g., relevant research papers, may be also posted on the course website or identified for download from the university library.

Recommended References:

- N. Watson, and J. Arrillaga, "Power Systems Electromagnetic Transients Simulation", *The Institute of Engineering and Technology*, London, UK, 2007, ISBN: 0852961065

- Juan A. Martinez-Velasco, "Transient Analysis of Power Systems: Solution Techniques, Tools and Applications", *John Wiley and Sons, Ltd.*, 2015, ISBN 978-1-118-35234-2

- P. Kundur, "Power System Stability and Control", *McGraw-Hill Inc.,* 1994, ISBN: 007035958X

- H.W. Dommel, "Digital Computer Solution of Electromagnetic Transients in Single-and Multiphase Networks," in *IEEE Transactions on Power Apparatus and Systems*, vol. PAS-88, no. 4, pp. 388-399, April 1969.

- P. Krause, O. Wasynczuk, and S. Pekarek, "Electromechanical Motion Devices", Second Edition, John Wiley & Sons Inc., USA, 2012, ISBN: 978-1-118-29612-7

- M.R. Patel, "Wind and Solar Power Systems", CRC Press, 1999

- Z. Popovic, B.D. Popovic, "Introductory Electromagnetics", *Prentice Hall*, New Jersey, US, 1999, ISBN: 0-201-32678-7. (Chapters 13 and 18)

- "User's Guide: A Comprehensive Resource for EMTDC", *Manitoba HVDC Research Center*, Canada, Feb. 2010.

Evaluation:

The final course grades will be determined based on the performances in five components: assignments, labs, project, midterm exam, and final exam. The weight for each component is given in the table below.

Component	Weight (%)
Assignments	10
Lab	10
Project	10
Mid-Term Exam	30
Final Exam	40

Assignments:

The objective of the assignments is to reinforce the covered material and enable the students to use what they learn. There will be five assignments. Each assignment requires the students to develop a power system model and investigate a case study based on the provided step-by-step instructions.

The students are allowed to discuss general approaches to problems with each other. However, each student is expected to **independently** develop the requested models, perform studies, and prepare/submit reports. In other words, the students are **not allowed to share** any files, models, codes, or solutions with each other.

Labs:

The lab sessions will help the students learn PSCAD and MATLAB software. Evaluation of the software models developed for the assignments will be also done during the labs. Attending the lab sessions is mandatory.

Project:

Students are required to complete a project that involves modeling, simulation, and analysis of a power system and investigate a real issue/challenge (decided in consultation with the instructor). The project provides the students with an opportunity to experience some of the challenges that they may face in their future work/research activities. A list of several suggested project titles will be provided and the students must choose one or submit their proposed subject before the mid-term exam. The instructions for the content of the proposals and the project requirements will be provided on the course website.

The project reports should be prepared according to the IEEE PES conference paper format (templates are available on the IEEE PES website). The deadline for submission of the project reports is the end of the last class. The project presentations will be made during the last class. All presentation slides must be submitted the day before the last class.

Mid-term and Final Exams:

The mid-term exam will cover all lectures before the midterm. The final exam will cover all course content. Both exams will be closed book. Non-programmable calculators will be allowed.

General:

A student who fails to obtain a passing grade in any of the aforementioned components (assignments, labs, project, mid-term exam, and final exam) shall receive a final grade not greater than 48%.

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 with the exception of 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. In addition, in the professional life of an engineer, the manner in which oral and written communications are presented is extremely important. To encourage the student to do so, the grades assigned to all written and oral work will take into account all aspects of presentation including conciseness, organization, neatness, use of headings, and the preparation and use of tables and figures.

Assignments and Project Report Submission:

All assignments and project reports must be submitted online via OWL. Each report must be submitted as a single **PDF** file along with the corresponding models, e.g. PSCAD file(s) or MATLAB codes, that are needed to reproduce the reported results. The files should not be compressed. The files should be properly named based on the associated assignment section.

All assignments and project reports are due by 23:55 on the due date. Late submissions will not be accepted. In case the assignment/report cannot be submitted through OWL (due to technical issues), the students can submit them by sending an email to the instructor.

Collaboration and Group Activity:

The assignments must be solved individually. However, all students are highly encouraged to collaborate with each other in learning the course content and the PSCAD software. Besides, for the course project, the students can form groups, collaborate with each other, and submit one report (encouraged but not necessary). The report submitted for each group project must include the names of all group members and a short description of each member's role/contributions.

Attendance:

Any student, who in the opinion of the instructor is absent too frequently from class in this course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

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

Use of Electronic Devices:

During lectures, students may use laptops, tablet computers, or smart phones to access the course OWL site. Students are not allowed to use any electronic devices other than non-programmable calculators during exams. Please contact the course instructor if this policy adversely affects the accessibility of the course.

Internet and Electronic Mail:

Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca/portal/) and making themselves aware of any information that is posted about the course. The students must use their Western e-mail accounts for all e-mail correspondence related to this course. The subject of the email should start with: ECE 9408/ECE 9048.

Cheating:

University policy states that cheating, including plagiarism is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which may include expulsion from the program. If you are caught cheating, there will be no second warning.

Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar). Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations.

The University of Western Ontario uses software for plagiarism checking. Students may be required to submit their written work in electronic form for plagiarism checking. 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).

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.