Department of Electrical and Computer Engineering
ECE 6605PD
Power System Protection and Relaying
Spring 2022

Details of this course syllabus are subject to change throughout the term.

Instructor Information

Instructor: Sahar Azad, Ph.D., PEng
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Note: When sending an email to the course instructor:

1. Ensure that the email's subject contains ECE 765.
2. The email is sent from a University of Waterloo mail server with your official UWid. Email from Gmail and the like will not be received.

Prerequisites: ECE 360, ECE464 or equivalent and general knowledge of fault analysis.

Course website

The course website is on LEARN and it contains all lecture materials, min-projects/solutions, and quizzes and it will be used as the primary medium for communication.

Piazza

If you have any questions, you can anonymously ask your questions on Piazza. If you don't have access to the course Piazza, you can sign up using the following link:

piazza.com/uwaterloo.ca/Spring2022/ece6605PD

This platform will give you the opportunity to ask your questions anonymously. You can answer each other's questions and I will also monitor the platform on a daily basis. A **2% bonus mark** will be given to the student who achieves the highest participation rate in Piazza in terms of responding to other studens' questions.

Course Description

This course focuses on the protection of various components of a power system including transmission lines, rotating machinery, transformers, busbars, reactors, capacitors and distribution lines. The course will review the fundamental features of a reliable protection system and will discuss the major components of a protection system including current and voltage transformers, circuit breakers, and relays. Various protection strategies such as overcurrent protection, distance protection, pilot protection and differential protection will be discussed in this course.

Course Goals and Learning Outcomes

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

A. Provide an in-depth understanding of power system protection requirements;
B. Describe the operational principle of the main components of a protection system;
C. Describe the fundamental principle of various protection methods for the main power system components including transmission and distribution networks, rotating machinery including generators and motors, transformers, and busbars;
D. Explain the advantages and disadvantages of various protection methods for each power system component and specify the proper protection method for the component in any given power system.

Course Content

- **Module 1-Protection system requirements (1 lecture):** Overview of power system structure, causes and types of faults, and protection system main requirements
- **Module 2-Elements of protection systems (2 lectures):** Relay types and operating principles, circuit breaker types and operating principles (optional), and instrument transformers types and operating principles
- **Module 3-Review of symmetrical components and power system fault calculations (2 lecture):** Balanced 3-phase faults, Unbalanced faults, Symmetrical components, and Sequence network construction
- **Module 4-Overcurrent protection (1 lectures):** Principles of overcurrent protection, fuses, sectionalizers and reclosers, time-delay overcurrent relays, and instantaneous overcurrent relays
- **Module 5-Coordination principle of overcurrent protection devices (2 lectures):** Guidelines for coordination of overcurrent protection devices
- **Module 6-Directional overcurrent relays (2 lectures):** Application of directional relays, and different connections and maximum torque angles
- **Module 7-Distance protection (2 lectures):** Distance relay characteristics, and factors affecting distance relay performance
- **Module 8-Pilot protection of transmission lines (4 lectures):** Communication channels, directional comparison blocking, directional comparison unblocking, direct underreaching transfer trip, permissive overreaching transfer trip, permissive underreaching transfer trip, and current-based pilot schemes
- **Module 9-Transformer protection (2 lectures):** Overcurrent protection, differential protection, and nonelectrical protection
- **Module 10-Busbar Protection (2 lectures):** Common busbar arrangements and busbar protection

- **Module 11-Generator protection (2 lectures):** Typical power plant layouts, grounding methods for generators and protection principle against stator faults, rotor faults, unbalanced currents, overexcitation, overspeed, abnormal voltages and frequencies, and loss of excitation
- **Module 12-Motor protection (2 lectures):** Motor failures, thermal protection, stall or locked rotor protection, short circuit protection, ground fault protection, load-loss/load jam protection, overspeed protection, unbalance current protection, undervoltage protection, and overvoltage protection

  Note: The number of lectures for each module may vary based on class progress.

Text and References (Recommended)

- Stanely H. Horowitz, & Arun G. Phadke, Power System Relaying, 4th edition, Wiley (Text-1)
- J.L. Blackburn, Protective Relaying: Principles and Applications, Taylor & Francis Ltd. (Text-2)
- J. Duncan Glover, Mulukutla S. Sarma & Thomas, J. Overbye, Power System Analysis and Design, 5th edition, CENGAGE Learning (Text-3)

Course Requirements and Assessment

The course grade will be based on six projects, five short quizzes and a final examination, which will be held during the official examination schedule. The breakdown is as follows:

Assessment	Weighting
Final Exam	30%
Mini project I	20%
Mini project II	20%
Mini project III	20%
Mini project IV	20%
Total	110%

The instructor reserves the right to use alternative grading schemes in special circumstances. For example, if an accommodation is necessary, an alternative grading scheme may be used to the benefit of the individual student.

MINI PROJECTS

- **Four mini projects** are to be given. The projects will be posted on LEARN after the corresponding modules are covered in class.
- **Each project is worth 20 marks and there are 110 marks in total in this course. Therefore, the projects will provide 10 additional (bonus) marks.**
- **These projects are a combination of analytical questions and simulation problems.**
- All projects should be neat and clear. Messy and crumpled solutions will not be marked.
- Late projects will not be accepted unless a legitimate reason (illness, religious conviction, etc.) is discussed with the instructor before the due date.
- Solutions to the projects will be posted on LEARN after the due date of the projects.

FINAL EXAM

- The final exam will be open book in the sense that you may consult your textbook, course notes, and materials posted on the course LEARN site. Use of any other resource (including file-sharing services such as chegg.com, coursehero.com, stackexchange.com, ...) is prohibited. You may not communicate directly or indirectly with any person except the course instructor.
- A student missing the final exam will automatically receive a score of zero for that exam.
- The instructor reserves the right to curve any of the project grades, and the final marks.

Information on Plagiarism Detection

Turnitin.com: Text matching software (Turnitin®) may be used to screen lab reports and assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography) if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin® in this course.
It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit the alternate assignment.

Academic Integrity

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility.

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4.

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals.

Other sources of information for students

Academic integrity (Arts) Academic Integrity Office (uWaterloo)

Accommodation for Students with Disabilities

Note for students with disabilities: The AccessAbility Services office, located in Needles Hall Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students

with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the AS office at the beginning of each academic term.