



Department of Electrical & Computer Engineering

ECE 662: POWER SYSTEMS ANALYSIS AND CONTROL FALL 2024

Class Schedule:

- The course comprises 12 three-hour lectures [REDACTED].
- For the Fall 2024 term, classes are scheduled for **Wednesdays from 10:00 am till 12:50 pm.**

Instructor / TA Information:

| Instructor | | |
|---------------------|-----------------|--|
| Name | Office &Ext | E-mail |
| Ramadan El-Shatshat | E3-4111 @ 37063 | raelshat@uwaterloo.ca |

Course Objective:

The main course goal is to provide students with a complete overview of interconnected power system operation. At the completion of the course students should be able to develop appropriate models for an interconnected power system, and know how to calculate the voltage, power and reactive power in the system under normal and abnormal operating conditions. Students should also be able to perform power flow analysis, fault analysis, and transient stability analysis and to write a basic power flow and/or short circuit analysis computer program.

Course Prerequisites:

Open to electrical engineering graduate students. Basic understanding of circuit analysis, electrical machines and transformers and some basic familiarity with MATLAB are assumed.

Content:

| No. of Weeks | Topics | Sub-Topics |
|--------------|---|--|
| 1 | Basic Concepts | Review of Phasors; Balanced 3 Phase (ϕ) Systems; Complex Power; Reactive Compensation; The per Unit System; Power transfer and reactive power; Useful network theory |
| 2 | Power System Components | <p>Synchronous Machines: Characteristics; Equivalent circuit, The operation of a generator on infinite bus; Salient-pole generator</p> <p>Transmission Lines: Types and Parameters; Representation of Transmission Lines; Transmission Line Models</p> <p>Power Transformers: Ideal transformer; Practical transformer; connection of 3 Phase transformer and phase shift; per-phase equivalent circuit; Autotransformer</p> <p>Loads: Load types; Load models.</p> |
| 2 | Power Flow Analysis and Control | <p>Basic Power Flow(PF) Problem: Basic bus types; Equality and inequality constraints; Problem solvability</p> <p>Solution of the PF Problem: Newton-Raphson (NR) method; NR applied to PF Equations;</p> <p>PF Approximations: Dishonest NR; Decoupled power flow; Fast decoupled power flow; DC power flow</p> <p>Power System Control: Indirect transmission line control; Analytic calculation of sensitivities; Analytic sensitivities; Operating areas; Area control error (ACE); Automatic generation control (AGC)</p> |
| 2 | Symmetric and Asymmetrical Fault Analysis | Fault types; Generator modeling during faults; Fault analysis solution techniques; Calculation of 3 phase balanced fault current; Methods of symmetrical components; Representation of a system in the phase sequence networks; Fault level in a typical system; Systematic methods for fault analysis in large networks; Bus impedance (short-circuit matrix) method; Neutral grounding |
| 2 | System Stability | Definition and classifications of stability; Simplified model of synchronous machine; The swing equation; Transient stability analysis; Transient stability solution methods; Equal area criteria; Transient stability calculations by computers |
| 2 | Compensation of Power Transmission Systems | Introduction; ideal shunt compensator; ideal series compensator; improvement of the voltage profile, power-angle characteristics, stability margin and damping to power oscillations using both types of compensators. |
| 2 | Voltage Stability | <p>Definitions.</p> <p>Voltage collapse: Basic concepts.</p> <p>Control and protection: Compensation; secondary voltage regulation; under-voltage relays.</p> <p>Voltage regulation: Basic concepts.</p> <p>Practical applications: A real blackout analysis.</p> |

Course References:

1. *Energy Systems: Analysis and Operation*, by A. Gómez-Expósito, A. J. Conejo and C. A. Cañizares, *CRC Press, July 2008, ISBN 0849373654*.
2. *Power System Analysis and Design*, by Glover, Sarma and Overbye, 5th edition, Thomson, 2011.
3. *Power System Analysis*, by J. J. Grainger & W. D. Stevenson, Jr., 1994, McGraw Hill Pub., ISBN: 0070612935
4. *Power System Analysis*, by A. R. Bergen and V. Vittal, Prentice Hall, 2nd Edition, 2000
5. *Power generation, operation and control*, by Wood & Wollenberg, Wiley-Interscience, 2nd Edition, 1994, ISBN 0-471-58699-4
The above references (1-5) are the course reference books, covering in more depth some of the topics touched on in the text.
6. *Lecturer Notes and Journal Papers*

Student Assessment:

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| • Course assignments | 20% |
| • Course Project | 30% |
| • Final examination | <u>50%</u> |
| • Total | 100% |

University Policy:

- **Academic integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]
- **Grievance:** A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.
- **Discipline:** A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for their actions. [Check the Office of Academic Integrity for more information.] 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 instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

- **Appeals:** A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72, Student Appeals.
- **Note for students with disabilities:** AccessAbility Services, located in Needles Hall, Room 1401, 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 AccessAbility Services at the beginning of each academic term.
- **Turnitin.com:** Text matching software (Turnitin®) may be used to screen 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 alternate assignment.