Department of Electrical & Computer Engineering

ECE 662: Power System Analysis and Control
Course Outline
Fall 2025

Instructor:
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Office hours: Wednesdays from 5 to 6 pm on Teams. However, some hours will be rescheduled due to Prof. Cañizares' travel commitments.

TA:
TBD

Lectures: Mondays from 2:30 to 5:30pm @ E5 4128, with a ~20 min break at ~1 ½ h.

Objectives:
- Understand the basic definitions, concepts, and controls associated with power flow, short circuits, and stability of power systems.
- Discuss in detail techniques and tools for power system analysis and their application, with a practical perspective.

Content:

No. of Hours	Topics	Sub-Topics
6	Review	• Basic power system elements and models: ◊ Generators. ◊ Transmission systems. ◊ Loads. ◊ FACTS. ◊ Renewable Energy Sources (RES).

3	Power Flow Analysis	• System model. • Equations. • Solution techniques: ◊ Newton-Raphson. ◊ Fast decoupled. ◊ Optimization. • Contingency analysis.
3	Short Circuit Analysis	• System model. • Faults: ◊ 3-phase. ◊ Single-phase-to-ground. ◊ Two-phase. ◊ Two-phase-to-ground. • Matrix analysis.
3	Basic Stability Concepts	• Nonlinear systems: ◊ Ordinary Differential Equations (ODE). ◊ Differential Algebraic Equations (DAE). • Equilibrium points: ◊ Definition. ◊ Linearization. ◊ Eigen analysis. • Stability regions.
6	Voltage Stability and Control	• Definitions. • Voltage collapse (long-term): ◊ Basic concepts. ◊ Tools: Continuation power flows; direct methods; indices. ◊ Control and protection: Compensation; secondary voltage regulation; under-voltage relays. ◊ System security and transmission congestion. ◊ Real blackout analysis. • Voltage regulation (short-term): ◊ Basic concepts. ◊ Fault-Induced Delayed Voltage Recovery (FIDVR). ◊ Real blackout analysis.
3	Small-perturbation Stability and Control	• Definitions and basic concepts. • Tools: Eigenvalue analysis. • Control and protection: ◊ PSSS. ◊ FACTS. • Real blackout analysis.
6	Transient Stability and Control	• Definitions and basic concepts. • Tools: ◊ Time domain analysis. ◊ Direct methods (energy functions and equal area criterion). • Real blackout analysis.

3	Frequency Stability and Control	• Definitions and basic concepts. • Control and protection: ◊ Primary and secondary frequency regulation. ◊ Automatic Generation Control (AGC). ◊ Under-frequency relays. • RES impact and controls • Real blackout analysis.
1.5	Resonance Stability and Control	• Electrical. • Torsional. • Examples.
1.5	Converter Driven Stability and Control	• Fast interactions. • Slow interactions. • Examples.

Recommended Text:
A. Gómez-Expósito, A. J. Conejo and C. A. Cañizares, Editors, *Electric Energy Systems: Analysis and Operation*, 2nd edition, CRC Press, June 2018, ISBN 9781315192246.

Other References:
1. A. R. Bergen and V. Vittal, *Power systems analysis*, Second Edition, Prentice-Hall, 2000.
2. J. Arrillaga and C. P. Arnold, *Computer analysis of power systems*, John Wiley, 1990.
3. P. Kundur, *Power System Stability and Control*, McGraw-Hill, 1994, ISBN 0-07-035958-X.
4. P. M. Anderson and A. A. Fouad, *Power system control and stability*, IEEE Press, 1994.
5. C. A. Cañizares, Editor, "Voltage stability assessment: concepts, practices and tools," IEEE-PES Power System Stability Subcommittee Special Publication, SP101PSS, May 2003.
6. Journal papers and technical reports (available on-line).
7. Course notes available at course website.

Requisites: Basic knowledge of power systems and modeling is required. Some basic familiarity with MATLAB is required.

Projects: Required if Auditing the course:
1. Power flow and short circuit analysis of the IEEE 14-bus test system using MATLAB and a power system analysis package TBD.
2. Stability analysis of the IEEE 14-bus test system using a power system analysis package TBD.

Marking:

Projects (2)	→	50 %	TBD
Final Exam	→	50 %	TBD

Important Notes:

- Academic Integrity: Please read www.uwaterloo.ca/academicintegrity/
- Grievance: Please read Policy 70, Student Petitions and Grievances, Section 4, at www.adm.uwaterloo.ca/infosec/Policies/policy70.htm.
- Discipline: Please read Policy 71, Student Discipline, at www.adm.uwaterloo.ca/infosec/Policies/policy71.htm, and Guidelines for the Assessment of Penalties at www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.
- Appeals: A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) at www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.