Department of Electrical & Computer Engineering

ECE 6613PD: Power System Analysis and Control
Course Outline
Fall 2022

Instructor:
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Lectures: TBA, 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.
4	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.
4	Small-perturbation Stability and Control	• Definitions and basic concepts. • Tools: Eigenvalue analysis. • Control and protection: ◊ PSSS. ◊ FACTS. • Real blackout analysis.
4	Transient Stability and Control	• Definitions and basic concepts. • Tools: ◊ Time domain analysis. ◊ Direct methods (energy functions and equal area criterion). • Real blackout analysis.

2	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.
2	Resonance Stability and Control	• Electrical. • Torsional. • Examples.
2	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:
1. Power flow and short circuit analysis of the IEEE 14-bus test system using DOME and MATLAB.
2. Stability analysis of the IEEE 14-bus test system using DOME.

Take Home MT: Based on problems presented and discussed during lectures regarding the various topics discussed in class during the first half of the term. Some problems will require the use of MATLAB and DOME.

Marking:

Projects (2)	→	40 %	TBD
Take Home MT	→	10 %	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.