ECE 4620 (5620) -- Power System Operation and Control

Instructor: G. Radman; ***Office***: PH 433; ***Office Hours***: 1:00–3:00 MWF; ***Email***: gradman@tntech.edu

Textbook:

Hadi Saadat, *Power System Analysis*, Third Edition, PSA-Publishing, 2010, ISBN: 978-0-9845438-6-1

Reference: J. Duncan Glover, Mulukutla S. Sarma, and Thomas J. Overbye, Power System analysis and Design, 5th Edition, Cengage Learning, ISBN: 978-1-111-42577-7.

Goals: *To have students understand the various aspects of power system operation. Design assignments provide insight into practical issues.*

Prerequisites by Topics:

1. Power flow analysis.
2. Power System Components (line, transformer, synchronous machine) models.

Topics:

1. Economic Dispatch.
2. Symmetrical Components and Fault Analysis.
3. Power System Protection: Circuit Breakers, Relays, Instrument Transformers (CTs, VTs), Protective Schemes.
4. Generator Voltage Control: Automatic Voltage Regulator (AVR) Loop.
5. Generation Control: Automatic Load Frequency Control (ALFC) Loop.
6. Transient Stability: Swing Equation, Equal Area Criterion, Multi-Machine Systems.
7. Dynamic Stability Analysis and Control: Linear Model, Eigen Analysis, PSS-Loop.

Course Objectives:

1. To teach the students how to find the power scheduling of each power plant in an interconnected power system in such a way as to minimize the operating cost.

2. To introduce to the students the principles of symmetrical components and sequence networks, and to teach them how to calculate the node voltages and the branch currents for a faulty system. Different kinds of faults including three-phase, line to ground, line to line, and double line to ground faults are to be considered.

3. To introduce to the students the art of designing protective circuits to reduce the impacts of faults that will inevitably occur in a power system, and to teach them how to choose circuit breakers, relays, and instrumentation devices CT's and VT's.

4. To introduce to the students the swing equation of a generator, and the equal area stability criterion for determining the stability of a one-machine infinite-bus system upon a major disturbance. Students are to be taught how to evaluate the stability of a multi-machine power system also.

5. To provide the students with a basic knowledge of controlling active and reactive power in a power system in order to keep the system in steady state in the face of small changes that occur in the course of normal operation. The Load Frequency Control (LFC) loop and the Automatic Voltage Regulator (AVR) loop are to be introduced to the students with an emphasis on the application of modern control theory.

Course Outcomes:

1. Given a power system with several power plants each with different cost function, students should be able to find the scheduling of each power plant to minimize the operating cost of the power system.

2. Given an n-bus power system, students should be able to calculate the voltages and currents at different points of the power system due to any kind of faults.

3. Given a power system with several generators, transformers, bus-bars, and transmission lines, students should be able to design a protective circuit for the system, select and size the instrumentation devices (CT's and VT's), and select the circuit breakers and the relays.

4. Given a one-machine infinite-bus (or a multi-machine) power system, students should be able to write the swing equations, and determine whether the system the system is transient stable for various kinds of major disturbances such as loss of lines, short circuits, or loss of turbine power.

5. Given a power plant connected to an infinite-bus power system, students should be able to model the related LFC and AVR loops, and assume a control scheme and a set point such that the system operate in steady-state with constant frequency and acceptable voltage profile.

Assessment Tools:

1. In-class exams are used to test outcomes numbers 1:5 for individual students.
2. Several design assignments are used to test outcomes number 1, 3, and 5. These assignments are spread out throughout the semester. Collaboration among students is encouraged.

Grading Scale: **A** $\geq$ 90%

B $\geq$ 80%, but < 90% **C** $\geq$ 70%, but < 80%

D $\geq$ 60%, but < 70% **F** < 60%

Grading Points:

Test-1: 20 points Test-2: 20 points

Short quizzes: 20 points Design project: 10 points

Final Exam: 30 point **TOTAL:** 100 points

No make-up quizzes will be given. Make-up tests will be given under exceptional circumstances.

Note for ECE-5620 Students

***Students** taking this course for ECE 5620 credit are required to do the following:*

1- *Do all that are required of ECE 4620 (75% of the overall grade).*
2- *Complete a comprehensive project satisfactorily resulting in a technical report (15% of the overall grade).*
3- *Perform a literature review on some advanced topic and write report (10% of the overall grade).*

ADA Statement:

Students with disabilities (as defined by the Americans with Disabilities Act (ADA)) should contact the instructor at the beginning of the semester or term regarding the accommodations necessary to complete the requirements of this course. The instructor will make reasonable adjustment to take into consideration the specific handicap of each student covered under the ADA.

Ethics:

Students are expected to uphold high standards of academic honesty. All work turned in must be the product of each individual student's scholastic effort. This especially prohibits any form of plagiarism such as copying any part of homework or computer files. Cheating occurs when any student obtains unauthorized assistance or submits work done wholly, or through negligence provides unauthorized assistance to others is also equally guilty of academic misconduct. Academic misconduct will result in an "F" for the final course grade for all parties involved. The instructor is required by University Policy to inform the Office of the Vice President for Student Services anytime a penalty is imposed for academic misconduct.

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ECE 4610 (5610) & ECE 4620 (5620) [*Saadat*]

ECE 4610 (5610) -- Power System Analysis:

Chap 1: The Power System and Electric Power Generation

Chap 2: Basic Concepts and Fundamentals of Power Systems

Chap 3: Generator and Transformer Models; the p.u. - system

Chap 4: Transmission Line Parameters

Chap 5: Transmission Line Steady State Performance & Operation

Chap 6: Power Flows Analysis

ECE 4620 (5620) -- Power System Operation and Control:

Chap 7: Optimal Dispatch of Generation

Chap 8: Synchronous Machine Transient Analysis

Chap 9: Three-Phase Balanced (or Symmetrical) Faults

Chap 10: Symmetrical Components & Unsymmetrical Fault

Chap 10 (from Glover): Power system protection (*take notes & see the reference*)

Chap 11: Stability in Power Systems

Chap 12: Power system control