EE 435 Electric Power Systems

Credits: 3

Instructor: Matthias Fripp

Textbook and other Required Materials: *Power System Analysis and Design,* Glover, Sarma and Overbye

Catalog Description: Design/operation of "the grid." History of electric power systems, three-phrase power, real and reactive power, transformers, transmission, distribution, circuit analysis, protection, load flow, load frequency control, optimal power flow, and renewable energy integration. Pre: MATH 243 (or concurrent) or MATH 253A (or concurrent). (Fall only)

Prerequisites/co-requisites: MATH 243 (or concurrent) or MATH 253A (or concurrent)

Class Schedule: 3 lecture hours per week

Topics Covered:

- History and trends in the electric power system
- Fundamentals – phasors, instantaneous and complex power, network equations, balanced three-phase circuits
- Power Transformers – representation of ideal and practical transformers, per-unit system
- Transmission Line Parameters – resistance, stray conductance, inductance and capacitance (4.7, 4.11, and 4.12 can be skimmed)
- Transmission Line Operation – approximations, differential equations, equivalent π circuit, lossless lines, constraints, reactive compensation
- Power Flows – the power flow problem, solution methods, control of power flow, fast decoupled power flow, "DC" power flow
- Power System Controls – maintaining balance between supply and demand, at the lowest cost
- Wind & solar power – integrating intermittent power sources

Course objectives and their relationship to program objectives:

Students will be able to participate in operating and adapting Hawaii's power system, including addressing the challenges of adopting large amounts of renewable power [contributes to program objectives 1, 2, 4]. They will also be prepared for more advanced study of power system operation and design [program objective 3].

Course outcomes and their relationship to program outcomes:

After completing the course, students will be able to complete the following tasks (numbers in square brackets identify related program outcomes):

- Distinguish between vertically integrated and restructured electric utilities and identify factors that led to these business models. [2, 4]
- Identify key advantages of 3-phase AC power over DC. [1, 2, 4]
- Convert between sinusoidal values and phasor equivalents and analyze three-phase

circuits using phasors and per-phase techniques. [1]
- Calculate voltage and current flows in circuits containing ideal and practical transformers, via per-unit or impedance referral techniques. [1, 6]
- Calculate resistance, inductance and capacitance of transmission lines per unit of length. [1, 2, 6]
- Use short, medium and long-line models to calculate transmission line voltage and current relationships and load limits. [1, 2, 6]
- Write nodal equations for network power flow and use iterative methods and power flow software to solve them. [1, 7]
- Calculate generator response to frequency excursions and estimate the generation adjustments needed to restore frequency. [1, 6, 7]
- Perform economic dispatch for a multi-generator system. [1, 2, 4, 7]
- Identify the key challenges and mitigation measures for renewable energy integration. [1, 2, 4]
- Write clear and accurate solutions to power system engineering problems. [1, 3, 7]

Contribution of course to meeting the professional component:
Engineering Topics: 100%

Computer Usage: Students use PowerWorld power flow software for about 20% of the homework problems. They also use matrix inversion and multiplication software (Matlab or Python) as part of a Newton-Raphson workflow for some homework assignments.

Design Credits and Features: EE 435 has 0.25 design credit. About 10% of the assignments focus on choosing appropriate equipment and settings to achieve desired technical or environmental objectives.

Person(s) Preparing Syllabus and Date: Matthias Fripp, Oct. 14, 2014. Revised by Matthias Fripp, Jan. 21, 2021.