# 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.