# Master Course Description for EE-455 (ABET sheet)

**Title:** Power Systems Dynamics and Protection

**Credits:** 4

## UW Course Catalog Description

**Coordinator:** Daniel Kirschen, Professor, Electrical and Computer Engineering

**Goals:** To learn the analytical techniques and vocabulary of fault analysis and transient stability, two major areas of power systems analysis. To provide an introduction to power system protection.

**Learning Objectives:** At the end of this course, students will be able to:

1. *Calculate* fault currents in simple circuits with paper and pencil.
2. *Write* computer programs that can calculate fault currents in larger systems.
3. *Solve* basic relay coordination problems
4. *Employ* a simple salient pole generator model in steady state and transient analysis.
5. *Solve* power system stability problems using the equal area criterion.
6. *Perform* time domain stability analysis on power systems.
7. *Discuss* the operation of electricity markets

**Textbook:** D.S. Kirschen, "Power Systems: Fundamental Concepts and the Transition to Sustainability" Wiley 2024. (This text is also used by EE 454.)

**Reference Texts:**

A.R. Bergen and V.J. Vittal, *Power Systems Analysis, 2th Ed.* Prentice-Hall, 2000.

J. D. Glover, T. J. Overbye, and M. S. Sarma, *Power System Analysis and Design, 6th Ed.* Cengage Learning, 2017.

**Prerequisites by Topic:**

1. Phasor circuit theory
2. Round rotor generator model
3. Per phase and per-unit equivalent circuits
4. Solution of linear differential equations by integration

**Topics:**

1. Symmetrical Components and Fault Current Calculation (3 weeks)
2. Stability (2 weeks)
3. Voltage Control (1 week)
4. Power Control (1 week)

5. Introduction to Design of Protection (2 weeks)
6. Introduction to Electricity Markets (1 week)

**Course Structure:** The class meets for two lectures a week, each consisting of two 50-minute sessions. There is weekly homework that includes small computer projects. There is one midterm examination, and a final examination.

**Computer Resources:** The computer projects can be done on any PC.

**Laboratory Resources:** None

**Grading:** 40% Homework, 30% midterm and 30% final exam.

**ABET Student Outcome Coverage:** This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(H)** This course has an extensive component of power system modeling and analysis. The vast majority of the lectures, homework and projects deal with the application of circuit theory and control theory to specific power system operating situations. Dynamic analysis using differential and integral equations is included in the stability work. Mathematical formulations are commonplace throughout the course. The homework, quizzes and final require solving engineering problems identified by the assignments and exemplified by class discussion. The projects challenge the students to identify the issues and formulate solutions in a broader context.

(2) *An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.* **(M)** There are two weeks of lecture on the design of protection systems (placement of protection devices and protection device settings), with associated homework, quiz and examination problems, worth about 20% of the course grade. There is one week of lecture on design for stability, covering various methods of improving power system stability, with associated homework, quiz and examination problems, worth 10% of the course grade. The midterm computer project is to write a program to perform power system fault analysis. The final computer project is to use existing software to improve the design of an existing, unstable system to achieve stability. Collectively, these projects account for about 30% of the course grade.

(3) *An ability to communicate effectively with a range of audiences.* **(L)** Students submit written reports on their computer projects.

(4) *An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.* **(M)** The course includes a unit on large-scale system stability which includes study of the social and economic impact of system instabilities on customers. This unit uses case studies to understand

the societal dependence on large utility grids and the extent of disruption when wide-area instabilities occur. Remedial actions that may have averted these historical disruptions are reviewed.

**Originally Prepared By**: Rich. Christie

**Revised by:** Daniel Kirschen

**Last revised:** 12/8/2024