Master Course Description for EE-457 (ABET sheet)

Title: Electrical Energy Distribution Systems

Credits: 4

UW Course Catalog Description

Coordinator: Daniel Kirschen, Professor, Electrical and Computer Engineering

Goals: The goal of this course is for students to learn the ability to understand, analyze and design electrical distribution systems.

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

1. *Understand* basic structure of distribution apparatus and systems.
2. *Solve* power distribution system problems
- *Complete* a final project to perform a distribution system design task and summarize

the problem and project results in a report. 3. *Calculate* distribution feeder reliability indices

Textbook: W.H. Kersting, *Distribution System Modeling and Analysis, 4th Ed.*, CRC Press, 2017.

Reference Materials:

1. L. Faulkenberry and W. Coffer, *Electrical Power Distribution and Transmission*, Prentice Hall, 1996.
2. T. Gonen, *Electrical Power Distribution System Engineering*, McGraw Hill, 1986.
3. J. Burkek, *Power Distribution Engineering: Fundamentals and Applications*, Marcel Dekker, 1994.
4. *Distribution System Protection Manual*, Cooper Power Systems.

Prerequisites by Topic:

1. Elementary power and energy concepts
2. Basic power system analysis
3. Basic transformer theory

Topics:

1. System Structure and Characteristics
2. Load Modeling
3. Distribution Transformer Schemes
4. Three-Phase Power Flow for unbalanced systems and Fault Studies
5. Voltage Regulation, Power Factor Improvement

6. Distribution Feeder Protective Devices
7. Protective Device Coordination
8. Reliability Analysis
9. Distribution Automation

Course Structure: The class meets for two lectures a week, each consisting of two 50-minute sessions. There is weekly homework and a final project. There are weekly quizzes or a midterm examination, and a final examination. The course includes a field trip to a local utility facility.

Computer Resources: Homework and software project can be done on any PC.

Grading: Homework 25%, Final Project 25%, Midterm Exam or Quizzes 25%, Final Exam 25%.

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)** The class includes various examples of power system operational problems such as feeder overload and voltage violations. Students are asked to identify problems from the system operating conditions (e.g. voltage profiles), cast the problem into an appropriate form (i.e. voltage support) and develop solutions (i.e. capacitor placement). In the final project, students identify and solve these problems in a larger context, e.g. when multiple issues are present in the system. Problem solution requires knowledge of distribution system modeling and analysis theory and practice. Mathematical models of distribution system components are integrated into a system. Students use circuit analysis techniques to calculate the voltages, currents, and power flows on unbalanced distribution feeders by implementing distribution system power flow algorithms, which are iterative numerical methods developed to solve the power flow problem.

(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)** Students write a three phase power flow program, and select and implement appropriate voltage control measures to achieve acceptable power quality for customers. Designs to support distributed energy resources (renewables) are part of the homework and projects.

(3) *An ability to communicate effectively with a range of audiences.* **(M)** The final project has an extensive written report. A grade for writing quality is given separately from technical content.

(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 discussions of the recent regulatory reform of the power industry throughout the

world. The course has a component on the characteristics of load for industry, commercial and residential users. Reliability analysis includes discussion of the problem that reliability is collective but individual users have different reliability requirements.

(5) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.* **(M)** The course project, which has intermediate goals throughout the course, is done by teams.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(L)** In the project, students must explore a range of operating conditions to evaluate feeder operation and identify problems requiring corrective action, and then to determine the success of their actions.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* **(L)** Students must learn to use a commercial distribution analysis tool, WindMil. While an introductory tutorial is provided, students learn features and uses beyond the tutorial. Students are asked to examine the literature to answer questions about current practices in distribution systems in one homework assignment.

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Last revised: 12/8/2024