EPRI | ELECTRIC POWER RESEARCH INSTITUTE

GEARED

GridEd

The Center for Grid Engineering Education

Unbalanced Distribution Systems Analysis

Course Description

This course is one in a series of several courses developed and offered by GridEd to address the evolving forces that will alter the fundamental operating characteristics of the electric grid, transforming it from a one-way central supply structure to one that has bidirectional power flows resulting from distributed energy resources (DER). This course focuses on analysis tools for unbalanced power systems. The physical and mathematical concept of a three phase balanced electric power system will be reviewed. Discussion will involve, how and when a balanced electric power system becomes unbalanced, why a distribution system could normally be unbalanced, and the importance of developing and using alternate mathematical models and methods of analysis to study unbalanced power systems. Examples will be used to compare the behavior of unbalanced distribution systems with balanced systems.

Who Should Attend

Engineers and other professionals with a background in college calculus and physics, particularly those interested in electric power systems.

Registration Information

PDH Available: 12 hours

Registration Fee:

- $1,200 per person
- 20% discount for organizations with three or more attendees
- 25% discount for government employees (non-utility)
- 25% discount for university professors*
- 75% discount for graduate students*

*University IDs required to qualify for professor or graduate student discounts.

Students need to bring: laptops or tablets to access online resources and to follow class notes. Wi-Fi access is provided. Lecture slides will be provided electronically in PDF format.

For More Information

Amy Feser, afeser@epri.com, (865) 218-5909

Course Instructors

Agustín A. Irizarry-Rivera, PhD, PE

Meet the Instructors

Agustín Alexi Irizarry-Rivera obtained his bachelor, Magna Cum Laude, at Universidad de Puerto Rico Mayagüez (UPRM) (1988), masters at University of Michigan, Ann Arbor (1990) and Ph.D. at Iowa State University, Ames (1996) all in electrical engineering. Since 1997 he has been Professor at the Electrical and Computer Engineering (ECE) Department UPRM where he teaches graduate and undergraduate courses such as: Fundamentals of Electric Power Systems, Power System Analysis, Advanced Energy Conversion, Power Systems Dynamics and Control and Transmission and Distribution Systems Design. Dr. Irizarry-Rivera conducts research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources in our energy portfolio. He has served as Consultant on renewable energy and energy efficiency projects to Puerto Rico's Government agencies, municipalities, private developers and consulting firms in and outside Puerto Rico. He has also served as expert witness in civil court cases involving electric hazard, shock or electrocution. He is author or coauthor of over 40 refereed publications including two book chapters. A licensed professional engineer in Puerto Rico since 1991 and member of IEEE.

Course Outline

Day 1

- **Brief introduction to electric power systems. Description of the physical system, assumptions made for analysis and the resulting mathematical model for:**
  - Generation
  - Transmission
    - Short, medium and long lines models
    - Balanced system thru design, transposition of lines and balancing of loads
  - Distribution: A balanced system? - A convenient untruth
    - Transposed lines?
    - Balanced loads?
    - Is the source balanced?
- **A balanced electric power system**
  - Advantages of a true balanced system
  - Mathematical constructs for a reasonably balanced system
    - Underlying assumptions
    - Reasonably balanced?
  - Single phase analysis
- **A balanced system turns unbalanced**
  - Faulted systems
    - Balanced before fault – traditional fault analysis
    - Symmetrical components
- **An unbalanced system**
  - Models
  - Analysis tools

Day 2

- **Analysis of unbalanced systems**
  - Examples using forward-backward sweep (hand calculations)
  - Examples using software too

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