

University of Pittsburgh, Swanson School of Engineering

Electrical & Computer Engineering Department

Power System Engineering & Analysis I (ECE-1769) – Fall 2009 Semester

Course Overview & Objectives:

ECE-1769 is a first course in modern power system engineering and analysis, emphasizing basic concepts in the power engineering discipline. ECE-1769 will provide junior or senior level students with a broad overview of the power engineering field, as well as to introduce students to the practical applications of power engineering concepts to today's power & energy industry environment.

Students will gain an appreciation of the diverse applications of various technology areas and engineering disciplines associated with the power & energy field; including elements of electrical circuit analysis, equipment design and operation, communications, applications of advanced devices, computer applications of network solutions and control, and an overall introduction to the electric power & energy industries.

The acquired understanding of these basic principles in power engineering will provide a strong foundation for further detailed studies in the power & energy engineering fields and related industry areas.

Detailed Course Description:

Starting from AC circuit background, phasor notation is used to describe power flow on single and three phase transmission lines. Single-line equivalent representations are used. Transformers are described from principles of magnetic circuits. Three phase transformers and auto-transformers are analytically described. Simplified per unit equivalents are applied to transformers for power transmission analysis.

Analytical equivalents for synchronous generators are developed. Their loading capability is described. Short circuit and transient response of generators is analyzed.

Geometric dimensions and conductor characteristics of three phase transmission lines are used to determine series reactance and shunt capacitance (line charging). Short length and long length equivalents are developed. Current and voltage relations are derived for transmission lines.

Networks consisting of generation, transmission, loads and compensating devices (capacitor banks, shunt reactors, FACTS technologies - SVC's, STATCOM's, etc.) are studied. Admittance and impedance models of the networks are derived and used for power flow.

Power flow on the network using software for Newton-Raphson methods is studied to solve the non-linear system computations of both small-scale and large-scale multi-bus / multi-component systems.

Network short-circuit (fault) calculations are used to size circuit breakers. Symmetrical components are introduced to describe unbalanced faults on the power system network.

Introductory concepts of emerging technology areas such as FACTS and HVDC, Smart Grids, and Energy Storage will also be studied.

Course Topics:

- Single Phase and Three Phase Power Transmission Systems
- Single Phase and Three Phase Power Transformers and Auto-Transformers
- Synchronous Three Phase Generators
- Three Phase Transmission Line Characteristics
- Power System Networks: Generation, Transmission, Distribution, and Loads
- Power System Network Impedance and Admittance Models
- Power Flow Representation and Calculation for Non-Linear Computation
- Power System Compensation Equipment: Capacitor Banks, Reactors, etc.
- Power Electronics Control Technologies: Static Var Compensators, High Voltage DC, etc.
- Real and Reactive Power Concepts
- Power System Network Short Circuit Calculations
- Symmetrical Components for Unbalanced Network Solutions

Course Pre-requisites: ECE-0041 – Linear Circuits and Systems II

Course Text: Glover and Sarma, "Power System Analysis and Design"; 4th Edition

Power & Energy Industry Overview, Opportunities, and Pittsburgh Significance:

The electric power & energy industries are experiencing the beginning of an opportunistic long-term growth transition. Following several decades of under-investment in major infrastructure and core systems, technology R&D, and organizational development (primarily due to years of industry de-regulation), the power & energy sector is emerging as a fast-growing, dynamic, and attractive area for top engineering talent. A major crisis within the industry is the aging workforce issue, for which an estimated 50% or more of all current power & energy industry technical professionals will retire over the next 10 to 15 years. Industry organizations are beginning to prepare for this situation, and are hiring large numbers of new engineers and other professionals, in order to provide a foundation for a long-term future of employment and organizational stability. There has never been a more exciting or dynamic time to enter the power & energy industry – a myriad of opportunities, challenges, and exciting careers are available for new graduates with power engineering and energy-related backgrounds and experience. In addition, the current Obama administration has placed great emphasis on power & energy research and project development funding, and in the process developing the beginnings of a new 'energy economy' with a focus on renewable and green energy resources, smart grids, energy storage, power electronics and other technological advances.

The Pittsburgh area provides a unique geographic center for the power & energy industry, with numerous local corporations (manufacturers, utilities, energy supplies, consultants, etc.) that operate in this economic and technical sector. Both global and local companies (such as Eaton Electrical, Westinghouse, CONSOL Energy, Convertteam, Duquesne Light, , Allegheny Power, Toshiba, Powerex, Siemens, ABB, Mitsubishi, Areva, Emerson, and others), all have either headquarters or major operations in the Pittsburgh region. Most, if not all, of these companies are growing and are in need of new graduating engineers. Many of them are former divisions, joint venture initiatives, mergers, or acquisitions of parts of the former Westinghouse Electric Corporation, a long time symbol of the power industry with its headquarters and major operations located in Pittsburgh. This Westinghouse "DNA" carries on in the new century through these many companies that remain loyal to the Pittsburgh region. Further, with the recent announcement of the Westinghouse Nuclear operations growth in the Pittsburgh area, increases in professional opportunities are expected to rise – not only at Westinghouse Nuclear, but overall with the numerous suppliers, manufacturers and other operations that support the nuclear generation business and synergistically other facets of the power & energy industry. In addition, the Pitt Power & Energy Initiative and Eaton Corporation's Electrical Group, headquartered in Moon Township, have established a partnership in Electric Power Systems. Including collaborations in various research areas, course and curriculum development, and plans for a new power systems laboratory.

Recent ECE-1769 Course Highlights (Fall 2006, 2007, and 2008 Semesters):

Recent ECE-1769 course highlights, from the past three fall semesters, include direct insight and expert knowledge of the power & energy industry markets and career opportunities. Direct, timely, and relevant industry knowledge is imparted throughout the classroom lectures, providing a strong complement of course theory with practical real-world applications. Industry-based materials and examples are used throughout the course, enhancing the learning environment and preparing students for realistic career experiences, including the application of industry standard modeling and simulation tools for project assignments. Past student evaluations of the recent ECE-1769 course far exceeded university norms for student satisfaction of both course and instructor ratings.

In addition, a "Power & Energy Industry Night" is held during each fall semester for the class, with five major industry corporations participating and providing students with an overview of their organizations, operations, and exciting career opportunities (including as many as 17 participating industry organizations). This special event provides students with a unique experience to learn first-hand from top industry engineers, managers, and executives the challenges they face and the career opportunities available for new graduates. Several students from each of the fall semester classes have found employment opportunities (either full time, co-op assignments, or as internships) with these and other local and national power & energy corporations. A similar event is already being planned for the fall 2009 semester.

Instructor Biography:

Dr. Gregory Reed is the Director of the Power & Energy Initiative in the Swanson School of Engineering at the University of Pittsburgh and an Associate Professor in the Swanson School's Electrical & Computer Engineering Department. As the first director of the new Power & Energy Initiative Dr. Reed provides the vision and leadership for the Swanson School of Engineering's multidisciplinary activities for the initiative's educational, research, and outreach components. He works closely with industry partners, federal and state agencies, foundations, and other constituents in collaboration with the Swanson School's faculty and staff and the university's Center for Energy on various funding and advanced research oriented efforts. Dr. Reed also teaches courses in the fields of electric power and energy engineering within the Electrical & Computer Engineering Department. His research interests include advanced power & energy generation, transmission, and distribution system technologies; renewable energy systems and resources; Smart Grid technologies; energy storage, power electronics, and control technologies; energy efficiency and power quality.



Dr. Reed has 23 years of industry and academic experience in the power and energy arena. He has authored or co-authored more than 60 papers and technical articles in the areas of electric power system analysis and the applications of power systems technologies.

Prior to his appointment at Pitt, Dr. Reed served as Senior Vice President of the Power System Planning and Management Group at KEMA, an international company headquartered in The Netherlands, providing power and energy consulting, technology implementation and market knowledge expertise. Prior to that, he served in various management and executive roles at Mitsubishi Electric Power Products, Inc. including Vice President of Power Systems Marketing & Technology Development. He began his career as an electric power systems engineer at the Consolidated Edison Co. of New York, Inc.

He is an active member of the IEEE Power & Energy Society, as well as a member of the American Society for Engineering Education (ASEE). He is currently a member of the IEEE PES Governing Board, serving as Vice President of Membership and Image. He also serves as the education working group

chair for the IEEE PES Power & Energy Engineering Workforce Collaborative, and is a member of the IEEE-USA Energy Policy Committee.

Dr. Reed's activities with various corporate partners include several European-based organizations and their European operations, such as KEMA Inc., Asea Brown-Boveri Inc. (ABB), and Siemens Corp.

Dr. Reed earned his Ph.D. in electrical engineering with a concentration in electric power from the University of Pittsburgh; his Masters of Engineering in electric power engineering from Rensselaer Polytechnic Institute; and his B.S. in electric power engineering from Gannon University.