CRN: 22679 ECET 499-01 Topics on Power System Analysis & Design

Fall 2017

Professor Paul I-Hai Lin, P.E. (States of CA & IN)
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Course Description:
Class 3, Lab 0-2, Cr. 4, P: instructor approval required
An overview of electric power system including transmission and distribution, power flow analysis, symmetrical components, short circuit fault calculations, symmetrical and unsymmetrical faults, system protection, and power distribution. Emphasis on applications of computer-based methods to power system problems using such tools as MATLAB, PowerWorld Simulator, and ETAP.

Lecture & Lab:
TBA, Room ET 205C
Course Web site: http://www.etcs.ipfw.edu/~lin

Instructor Information
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Text Book: Power System Analysis and Design, 5th Ed, by J.D. Glover, M.S. Sarma and T. Overbye, published by Cengage Learning, ISBN-13 978-81-315-1635-5

Reference Books:
- IEEE Recommended Practice for Electric Power Distribution for Industrial Plants, IEEE Std 141-1993, Red book.
- IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems, IEEE Std 242-1986, Buff book.
- Elements of Power System Analysis, William D. Stevenson, Jr., 4th Edition, published by McGraw-Hill.
- Handbook of Electric Power Calculations, 2nd Edition, by A. Seidman, H. W. Beaty, and H. Mahrous, published by McGraw-Hill
- Power System Analysis, by Hadi Saadat, published by McGraw-Hill
- Electric Power Distribution and Transmission, by L. M. Faulkenberry and W. Coffer, published by Prentice-Hall

ECET 499 Course Outcomes:

Upon completion of this course, students will be able to:
- Have a basic understandings on modern power system operation and protection
- Able to perform apply basic modeling technics for power system analysis
    - Modeling of power system apparatus (transformers, motors, transmission lines)
    - Single and three phase systems

- Conduct power flow analysis
    - Bus admittance matrix
    - Power flow solution
- Perform symmetrical and unsymmetrical fault calculations

Computer Usage:

1. World Wide Web and Internet information search, and Web browser.
2. MATLAB for technical computation
3. PowerWorld Simulator
4. ETAP

Grading Policy

Hw Assignments (evaluated through in-class quizzes) – 60%
Case Studies - 30%
Class Engagement & Attendance – 10%

Tentative Schedule/Activities

Week #	Chapters and Topics
Weeks 1-3	**Introduction to the Course** • **History of Electric Power Systems** • **Electric Power Generation, Transmission and Distribution** • **Electric Utility Industry Structure** • **Computers in Power System** • **Tools: MATLAB, PowerWorld, ETAP (25 seats academic license donation, acquired by Dr. David Momoh)** **Electrical Safety** **Environmental consideration** **Power Fundamentals:** • **Power triangles, Phasors, Complex power** • **Network equations, Balanced three-phase circuits,** • **Power in balanced three-phase circuits** • **Per-Unit quantities** **Additional References** *** Delivery -** **http://c03.apogee.net/contentplayer/?coursetype=foe&utilityid=indianamichiganpower-in&id=4451** *** Generation -** **http://c03.apogee.net/contentplayer/?coursetype=foe&utilityid=indianamichiganpower-in&id=4524** *** Safety -** **http://c03.apogee.net/contentplayer/?coursetype=foe&utilityid=indianamichiganpower-in&id=4651**

Weeks 4-5	**Electric Power Transformers**
	• **Transformer principles**
	• **Equivalent circuits for practical transformers**
	• **Three-phase transformer connections and phase-shift**
	• **PU equivalent circuits of balanced three-phase two-windings transformers**
	• **Three-windings transformers**
	• **Auto-transformers**
	
	Distribution Transformers
	• **Equivalent circuit**
	• **Types of distribution transformers:**
	  ○ **Power transformers: for substations and connection to large commercial and industrial customers)**
	  ○ **Autotransformers: used in transmission and sub-transmission substations**

	○ **Distribution transformers** ○ **Instrumentation transformers** **Instrumentation Transformers** • **Current transformers** • **Potential transformers** • **Applications of CT and PT in power systems**
Weeks 6-7	**Transmission Lines and Line Impedance** • **Types of conductors** • **Resistance, inductance, and capacitance** • **Calculations of line impedance** • **Shunt admittances** • **Impedance and reactance diagrams** • **Parallel circuits – three-phase lines** **Transmission Lines: Steady state operation** • **Medium and short line approximation** • **Equivalent PI circuit** • **Maximum power flow** • **Line loadability**
Weeks 8: Oct. 10	**Fall break**
Week 9	**Power Flows** • **Direct solutions to linear algebraic solutions: Gauss elimination** • **Iterative solutions to linear algebraic equations: Jacobi and Gauss-Seidel** • **Iterative solutions to nonlinear algebraic equations: Newton-Raphson** • **The power flow problems** • **Control of power flow** • **Fast decoupled power flow** **MATLAB Simscape, "Build and simulate a simple circuit,"** https://www.mathworks.com/help/physmod/sps/powersys/ug/building-and-simulating-a-simple-circuit.html?requestedDomain=www.mathworks.com
Week 10	**Symmetrical Faults** • **Series R-L circuit transients** • **Three-phase short circuits – unloaded synchronous machine** • **Power system three-phase short circuits** • **Bus impedance matrix** • **Circuit breaker and fuse selection**
Week 11	**Symmetrical components** • **Definition of symmetrical components** • **Sequence networks of impedance loads** • **Sequence networks of series impedances** • **Sequence networks of three-phase lines** • **Sequence networks of rotating machines** • **Per-unit sequence models of three-phase two-winding transformers** • **Per-unit sequence models of three-phase three-winding transformers** • **Power in sequence networks**
Week 12	**Unsymmetrical Faults** • **System representation** • **Single line-to-ground fault** • **Line-to-line fault** • **Double line-to-ground fault** • **Sequence bus impedance matrices**
Weeks 13-14	**System Protection** • **System protection components** • **Instrumentation transformers**

	• **Over current relays** • **Radial system protection** • **Reclosers and fuses** • **Directional relays** • **Protection of two-source system with directional relays** • **Zones of protection** • **Line protection with impedance (distance) relays** • **Differential relays** • **Transformer protection with differential relays** • **Pilot relaying** • **Digital relays**
Weeks 15-16	**Power Distribution** • **Introduction to distribution** • **Primary distribution** • **Secondary distribution** • **Transformers in distribution systems** • **Shunt capacitors in distribution systems** • **Distribution software** • **Distribution reliability** • **Distribution automation** • **Smart grids** **CPET 581 SmartGrid & Energy Management, Fall 2013, course instructor, Paul I-Hai Lin, http://www.etcs.ipfw.edu/~lin/CPET581-SmartGridEnergyManag/cpet581-SmartGridEnergyMang-Homepage-2013F.html**