

### **EL 6653 Power System Stability**

Introduction to the study of power system dynamics: mathematical modeling of prime movers, power plants, synchronous machines, field exciters transmission lines, relay loads and stabilizers. The course will present theoretical and practical aspects of AC power system stability analysis. The course will include extensive calculations and real world, practical examples that will provide a foundation for computer-based studies that can be utilized in real-world applications. The following topics will be covered to provide a foundation; power system modeling, short circuit calculations, load flow analysis, motor starting and equipment applications.

#### **Instructor**

Mark B. Cavallaro, P.E.  
Phone: 914-347-8480, Ext 11  
Fax: 914-347-8483  
Email: [mcavallaro@currentsolutionspc.com](mailto:mcavallaro@currentsolutionspc.com)

#### **Prerequisites**

1. Graduate Status.
2. EL 5613 Introduction to Electric Power Systems.
3. EL 6253 Linear Systems.
4. EL 6633 Transients, Surges and Faults in Power Systems.
5. Knowledge of Power Distribution Systems.
6. Fundamental knowledge of Power System equipment and components.
7. Ability to read, understand and develop power system one-line diagrams.

#### **Course Textbooks**

"Power System Analysis: Short-Circuit Load Flow and Harmonics" by J.C. Das; Publication Date: April 17, 2002; CRC Press Taylor & Francis Group.

"Power System Control and Stability" by Paul M. Anderson & A.A. Fouad; Publication Date: October 17, 2002 - 2 edition; Wiley-IEEE Press, IEEE Press Power Engineering Series

#### **Class Schedule**

Monday evenings 5:45 PM to 8:15 PM

#### **Grading**

- |                        |            |
|------------------------|------------|
| • Homework:            | 70%        |
| • Class Participation: | <u>30%</u> |
| TOTAL                  | 100%       |



### **Homework**

Readings and problems will be assigned regularly to re-enforce the class material presented. Problems will be collected and graded. Students are expected to complete all readings and all problems independently. Completion of readings and homework indicate that the student is studying and working towards learning from the course, therefore have an impact on the final grade. Any work submitted must be neat and detailed and include the students printed name and signature. The student signature will signify the students pledge that the work submitted is the students' own work, and no unauthorized assistance was obtained or utilized. Violators will be subject to academic misconduct which might lead to dismissal from the university and the program.

### **Class Participation and Attendance**

Class attendance and participation is very important and is considered in your overall performance in the course. Note that class participation is a significant part of your grade. Should students be absent you are responsible for all material covered in the missed class. Each student will be required to sign an attendance sheet for each class acknowledging attendance. It is each student's responsibility to sign the attendance sheet, if any student does not sign although in attendance the lack of signature will be the same as being absent.

Real world problem-solving sessions will be conducted in the classroom to apply and reinforce the textbook readings. Students are expected to bring a scientific calculator to each lecture for classroom workshops that will demonstrate how to create power system models and perform calculations.

### **Course Outline**

1. Power System Analyses
  - a. Summary of Different Types of Analyses
  - b. Significance of each to others
  - c. Summary of application.
2. Electrical Equipment Summary
  - a. High, medium and low voltage devices, switchgear and equipment
  - b. Application and Electrical Equipment Ratings
  - c. Protective Relays, Fuses & Circuit Breakers
  - d. Conductors & Bus
  - e. Function & use
  - f. Equipment Characteristics
  - g. Basic Models: Generator, Transformer & Electric Machine
  - h. Equipment Theory & Modeling
3. System Modeling
  - a. Impedance of Components
  - b. Model representation
  - c. Detailed & Approximate Modeling
  - d. Stability Criteria & System Controls
  - e. System Loads & Load Modeling: Motors, Drives, & Acquisition of Load Parameters
  - f. Generation: Generator, Exciter, Voltage & Frequency Regulators, Prime-Mover
  - g. Equipment: Transformers, Cables & Lines
4. Review of Three-Phase Power Calculations

**Polytechnic Institute of NYU**  
**Syllabus for Power System Stability - EL 6653**  
**Fall Semester 2009**

Page 3 of 4

- a. Per-unit modeling for analyzing power systems
  - b. Transformer connections and winding polarity
  - c. Phase shifts in delta-wye transformers
5. Short Circuit Theory and Terminology
    - a. Effects of Short Circuits
    - b. Fault Current Sources
    - c. Machine Reactances
    - d. Fault Current Characteristics
  6. Balanced Fault Calculations
    - a. Data Collection
    - b. Impedance Calculations
    - c. Momentary and Interrupting
    - d. Duty Calculations
  7. Symmetrical Components Fundamentals and Sequence Networks
    - a. Impedance and sequence network connections for modeling transformer banks
    - b. Fault calculations for three-phase and unbalanced faults
    - c. Unsymmetrical Fault Calculations
    - d. Current Interruption in AC Networks
    - e. Short-Circuit of Synchronous and Induction Machines
    - f. Short-Circuit Calculations
  8. Equipment Protection and Coordination
    - a. Conductors, Transformers, Motors
    - b. Coordination Fundamentals
    - c. Procedures & Data Collection
    - d. Plotting Time/Current Curves & Coordination Intervals
  9. Arc Flash Analysis
    - a. Impact of Short Circuit Calculations
    - b. Need for Device Coordination Data
    - c. Arc Flash Hazard Analysis Calculations using IEEE-1584
    - d. Arc Flash Standards and their Application
  10. Load Flow
    - a. Power Transmission Lines
    - b. Load Flow Methods & Power Flow Solutions
    - c. Reactive Power Flow and Control
    - d. Three-Phase and Distribution System Load Flow
  11. Power System Stability
    - a. Definition & Classification
    - b. Brief Description Of Stability Categories
    - c. Control & Protection
    - d. Active & Reactive Control in Power Systems
  12. Synchronous Machines
    - a. Theory & Simplified Models
    - b. Machine Parameters



**Polytechnic Institute of NYU**  
**Syllabus for Power System Stability - EL 6653**  
**Fall Semester 2009**

Page 4 of 4

- c. Transient & Sub-Transient Parameters
  - d. Synchronous Machine Representation in Stability Studies
  - e. One Machine Connected to Infinite Bus
13. Excitation Systems
- a. Elements of Excitation Systems
  - b. Types of Excitation Systems
  - c. Dynamic Performance Measures
  - d. Control & Protective Functions
  - e. Modeling of Excitation Systems
14. Stability Analysis, Loads & Control
- a. Power Angle Curve
  - b. Transfer Reactance
  - c. Swing Equations
  - d. Steady State Stability Theory & Practice
  - e. Performance of Protective Relaying
  - f. Transient Stability
15. Loads & Controls
- a. Basic Concept of Control
  - b. Nature of Control Problems
  - c. Active Power & Frequency Control
  - d. Reactive Power & Voltage Control
  - e. Methods of Voltage Control
  - f. Tap Changing Transformers
16. Multi-Machine Systems
- a. Reference Frames
  - b. Saturation
  - c. Integration Methods

**Other Useful and Recommended Books**

1. "Power System Dynamics and Stability" by P. Sauer and M.A. Pai, 1998, Prentice-Hall.
2. "Power System Stability and Control" by P. Kundur, 1994, McGraw-Hill.
3. "Power System Dynamics: Stability and Control" by K. Padiyar, 1996, John Wiley.
4. "Power System Stability and Control" by L. Grigsby, 2007, CRC Press.
5. "Symmetrical Components for Power Systems Engineering" by J. Lewis Blackburn, 1993, Marcel Dekker.
6. "Power System Analysis" by W. Stevenson and J. Grainger, 1994, McGraw-Hill.
7. "Power System Analysis" by Charles Gross, 1986, John Wiley & Sons.

The above Syllabus is subject to revisions. Revisions will be noted by date and revision at the bottom.

EL 6653 Power\_System\_Stability\_Syllabus 082609