First Course on Power Systems

• What topics should be included?
• What has changed from electrical engineering education in the past?
• What is inspiring new student interest?
• How are we addressing the need?

Bruce Wollenberg
How is electric power produced?

- Students have not had a “machines” course
- Most students have not had a thermodynamics course
- Most students do not know how electric power is produced
What does “three phase” mean?

- Most introductory circuit analysis courses do not teach three phase
- Most do not cover AC power adequately
- Reactive power? Transformers?
What is “The Grid”
How do we make connections at 345kV?

- What’s so special about circuit breakers?
- Why also have disconnect switches?
- Why do we raise and lower voltage?
What can go wrong?

- Fault analysis using symmetrical components
- Protection with relays
Why are students so excited about renewables?
Wind Generation

How do we generate at 60 Hz from variable speed wind?
What can go wrong with wind generation?
Will we need more transmission? You betcha!
Balanced Coverage of Topics

- Changing Landscape and Resources
- Apparatus in Generation & Delivery of Power
- Analysis and Operation
- Fault Protection

Textbook:
- Presentation Slides
- Solutions Manual
- Online Problems
Labs are all computer based
Test Power System

Software
- MATLAB/Simulink
- PowerWorld
- EMTDC/PSCAD
The above simulation is with $D_1=0.75/\text{wsyn}$ and $K_1=0.001/\text{wsyn}$ with time constants $T_{g1}, T_{s1}$ in seconds.
Lab using PowerWorld
Lab using EMTP/PSCAD
Topics Included

- Changing Landscape, Distributed generation (DG)
- Energy Sources, Renewables, Environmental Consequences
- Synchronous generators
- AC Transmission Lines and Cables; HVDC Lines
- Power Flow
- Power Electronics based FACTS Controllers
- Types of loads; Power Quality
- Voltage Stability
- Transient Stability
- Interconnected Systems
- Short-Circuit Faults, Relays, Circuit Breakers
- Switching Transients, Surge Arresters
Power Systems Lab – free to download:

Lab Manual - Experiments

1. Visit to a Local Substation/Generating Plant
2. Familiarization with PSCAD/EMTDC
3. Obtaining Parameters of a 345 kV Transmission Line and Modeling it in PSCAD/EMTDC
4. Power Flow using MATLAB and PowerWorld
5. Including Transformers in Power Flow using PowerWorld and Confirmation by MATLAB
7. Power Quality
8. Synchronous Generators
9. Voltage Regulation
10. Transient Stability using MATLAB
11. AGC using Simulink and Economic Dispatch using PowerWorld
13. Switching Over-Voltages and Modeling of Surge Arresters using PSCAD/EMTDC

CD with 18 Video Clips

1. Installation of PowerWorld and PSCAD-EMTDC
2. Familiarization with using PSCAD-EMTDC
3. Obtaining Parameters of Transmission Line using PSCAD/EMTDC
4. Simulating a Transmission Line in a Power System using PSCAD/EMTDC
5. Power Flow using PowerWorld
6. Power Flow using MATLAB
8. Including an HVDC Transmission Line for Power Flow in PowerWorld
9. Modeling of Thyristor Converters in PSCAD-EMTDC
10. Power Quality Calculations using PSCAD-EMTDC
11. Modeling of Synchronous Generators using PSCAD-EMTDC
12. Voltage Regulation by Thyristor Controlled Reactors (TCR) using EMTDC
13. Thyristor Controlled Series Capacitors (TCSC) using PSCAD-EMTDC
14. Transient Stability using MATLAB
15. AGC using Simulink
16. Transmission Line Short Circuit Faults using PowerWorld
17. Tripping of Transmission Lines due to Overloads using PowerWorld
18. Switching Over-Voltages and Modeling of Surge Arresters using EMTDC

Software:
MATLAB/Simulink
PowerWorld
PSCAD-EMTDC