

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?

- n Students have not had a “machines” course
- n Most students have not had a thermodynamics course
- n Most students do not know how electric power is produced



What does “three phase” mean?

Michigan Public Service Commission

Report on August 14th Blackout

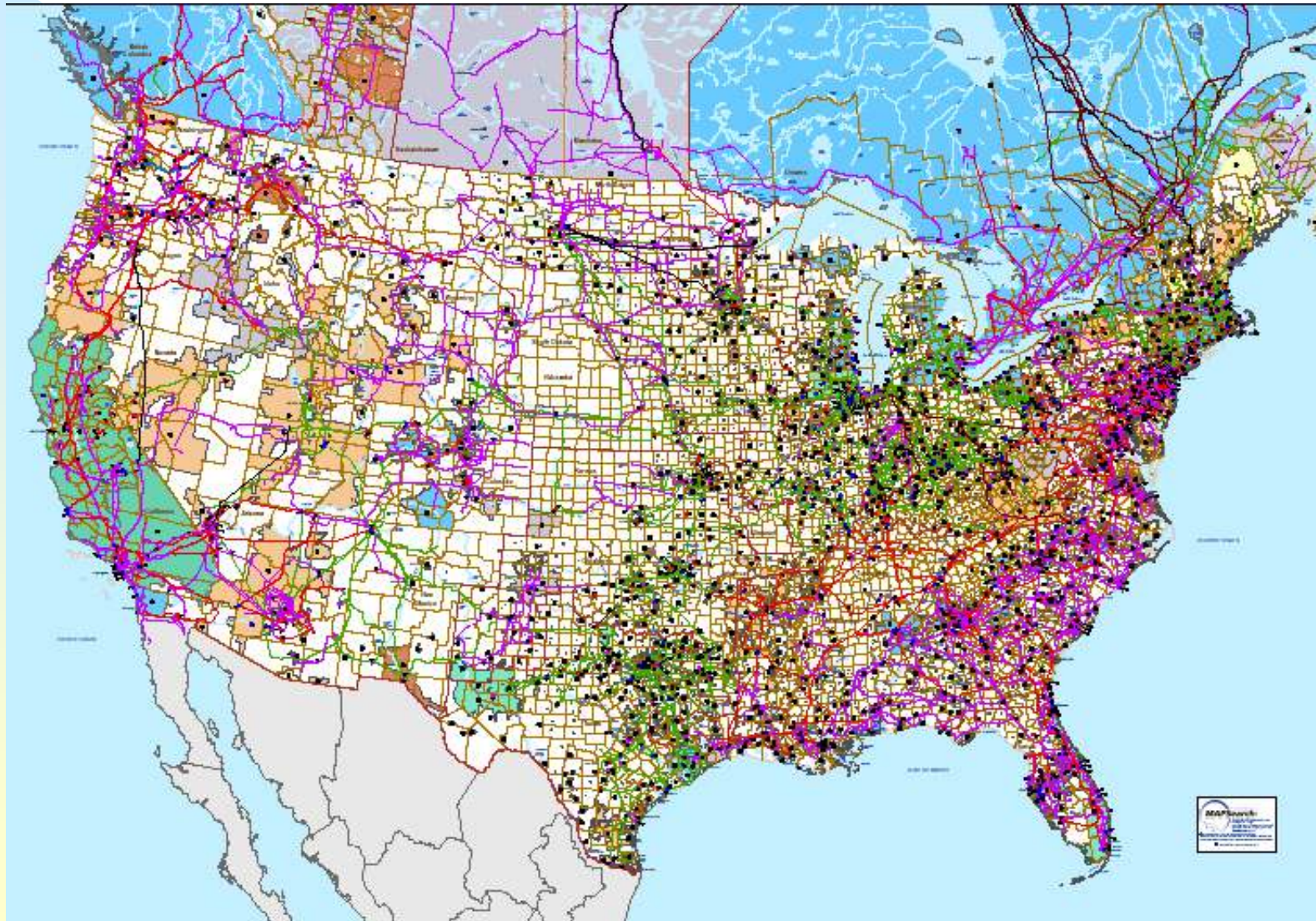
November 2003



- n Most introductory circuit analysis courses do not teach three phase
- n Most do not cover AC power adequately
- n Reactive power? Transformers?



What is “The Grid”



How do we make connections at 345kV?

- n What's so special about circuit breakers?
- n Why also have disconnect switches?
- n Why do we raise and lower voltage?



What can go wrong?



- n Fault analysis using symmetrical components
- n Protection with relays



Why are students so excited about renewables?



Wind Generation

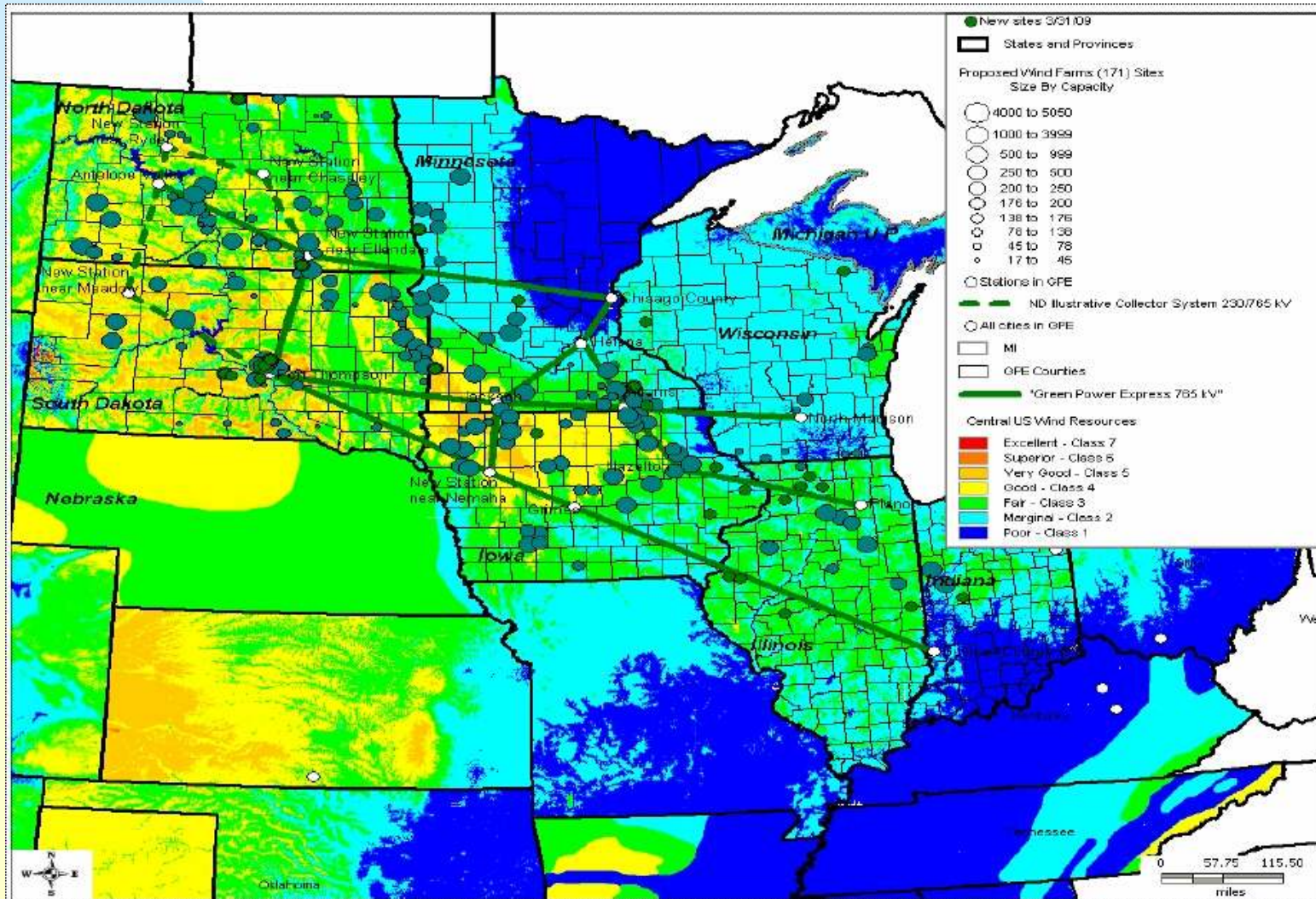


- n How do we generate at 60 Hz from variable speed wind?

What can go wrong with wind generation?



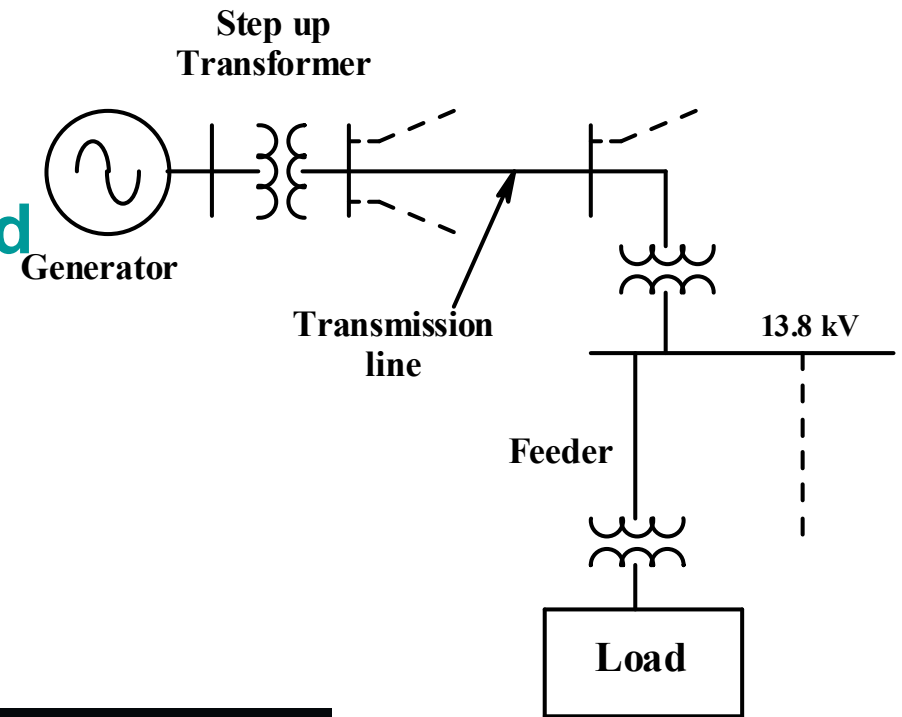
Will we need more transmission? You betcha!



Green Power Express

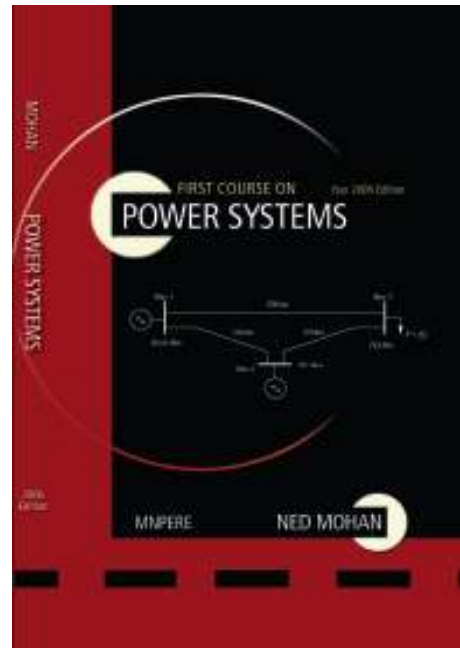
n **Balanced Coverage of Topics**

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



Textbook:

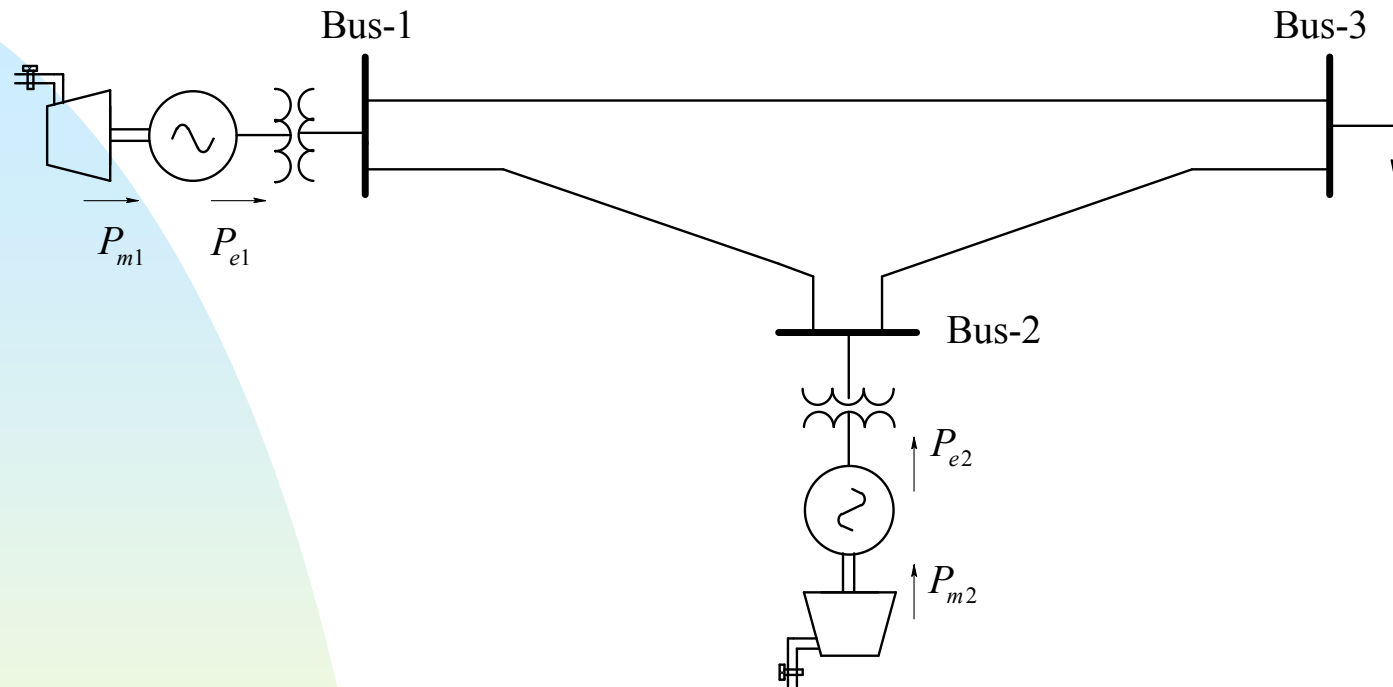
- Presentation Slides
- Solutions Manual
- Online Problems



Labs are all computer based



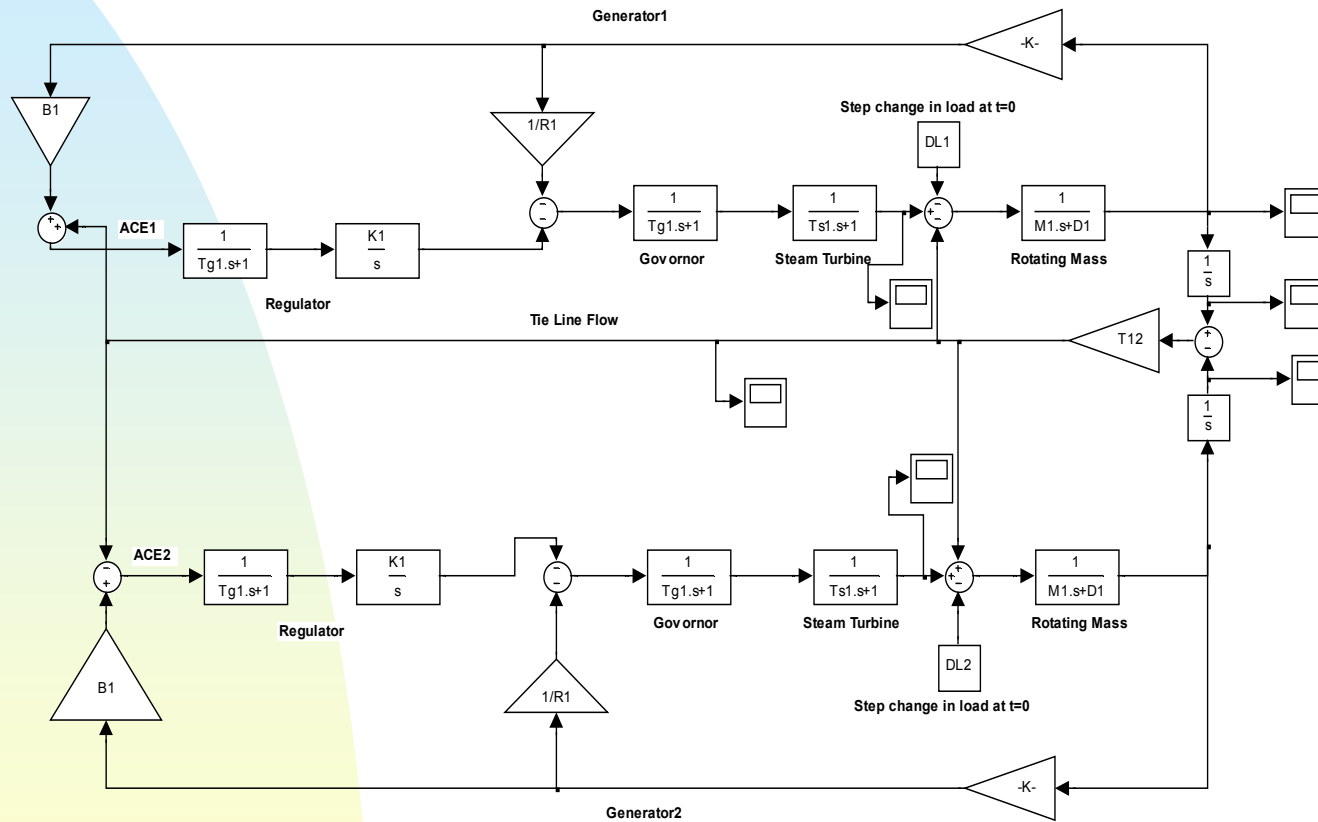
Test Power System



Software

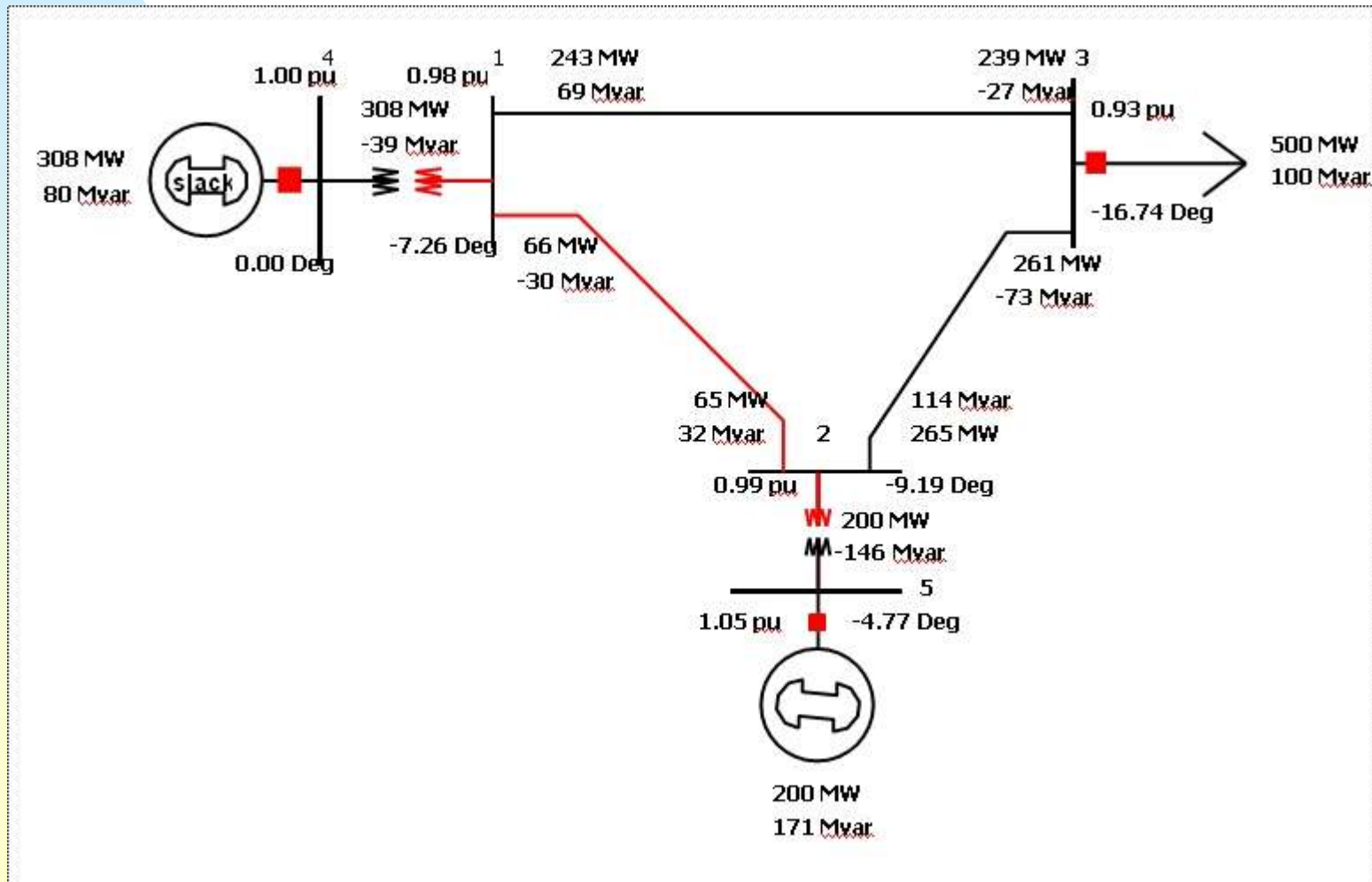
- MATLAB/Simulink
- PowerWorld
- EMTDC/PSCAD

Lab using Simulink



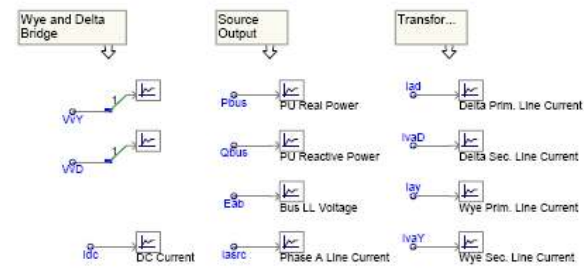
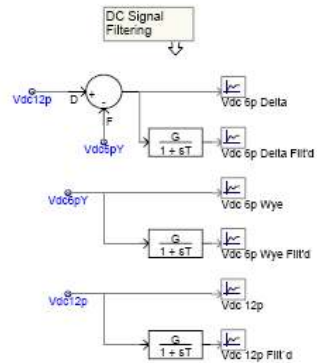
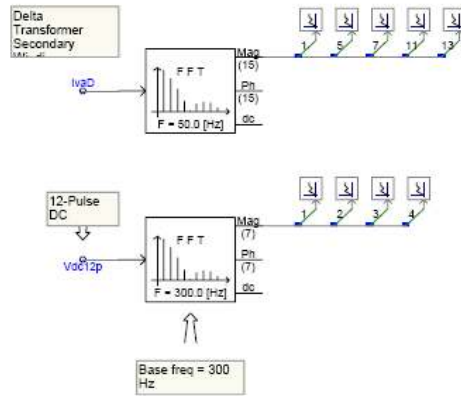
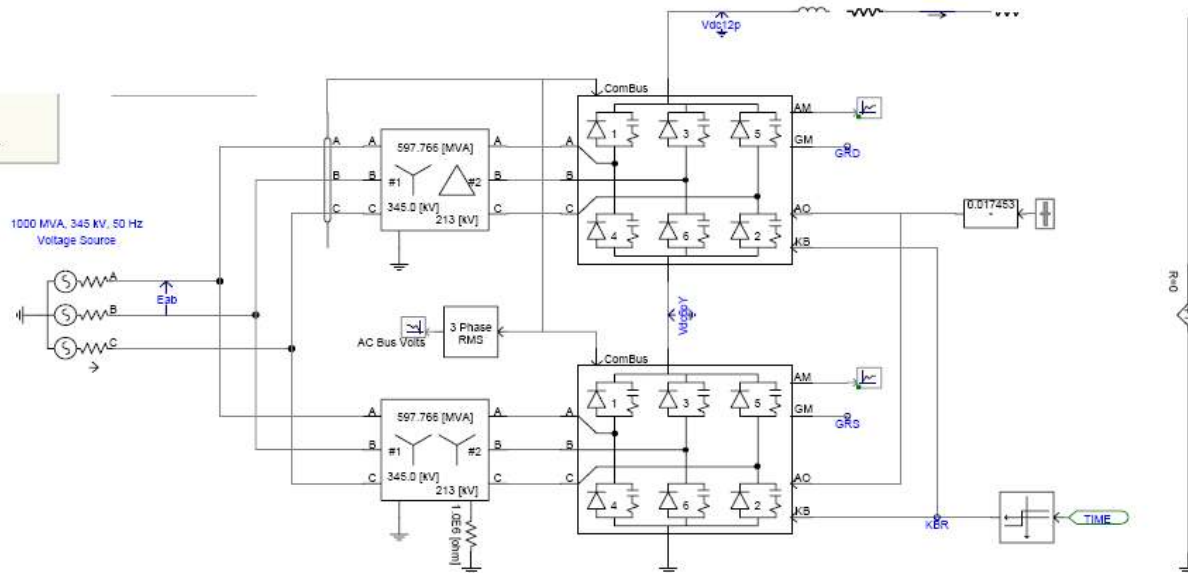
The above simulation is with $D1=0.75/w_{syn}$ and $K1=0.001/w_{syn}$ with timeconstants $Tg1, Ts1$ in seconds

Lab using PowerWorld



Lab using EMTP/PSCAD

Course 24.799 - HVDC
Transmission I
Dr. Anil Gole
Converted to V.3.x by J.
Nordstrom



Topics Included

- n Changing Landscape, Distributed generation (DG)
- n Energy Sources, Renewables, Environmental Consequences
- n Synchronous generators
- n AC Transmission Lines and Cables; HVDC Lines
- n Power Flow
- n Power Electronics based FACTS Controllers
- n Types of loads; Power Quality
- n Voltage Stability
- n Transient Stability
- n Interconnected Systems
- n Short-Circuit Faults, Relays, Circuit Breakers
- n 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
6. Including an HVDC Transmission Line for Power Flow Calculations in PowerWorld and Modeling of Thyristor Converters in PSCAD/EMTDC
7. Power Quality
8. Synchronous Generators
9. Voltage Regulation
10. Transient Stability using MATLAB
11. AGC using *Simulink* and Economic Dispatch using *PowerWorld*
12. *Transmission Line Short Circuit Faults using MATLAB and PowerWorld, and Overloading of Transmission Lines using PowerWorld*
13. Switching Over-Voltages and Modeling of Surge Arresters using PSCAD/EMTDC

CD with 18 Video Clips



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|-----|--|
| 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 |
| 7. | Including Off-Nominal Turns-Ratio and Phase-Shifting Transformers in Power Flow using PowerWorld |
| 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 <i>Simulink</i> |
| 16. | Transmission Line Short Circuit Faults using PowerWorld |
| 17. | Tripping of Transmission Lines due to Overloads using <i>PowerWorld</i> |
| 18. | Switching Over-Voltages and Modeling of Surge Arresters using EMTDC |

Software:

MATLAB/Simulink

PowerWorld

PSCAD-EMTDC