Power System Dynamics and Stability

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PhD Program: "Technical and Economical Management of Generation, Transmission and Distribution Electric Energy Systems".

Credits: 3

Note

This course is partly based on the course ECE664 hold by Prof. Dr. C. Cañizares at the University of Waterloo, Ontario, Canada. I wish to sincerely thank Prof. Dr. C. Cañizares for his courtesy in sharing this material.

Objectives

Understand the modeling and simulation of power systems from phasor analysis to electromagnetic transients.

Discuss the basic definitions, concepts and tools for stability studies of power systems.

Familiarize with basic concepts of computer modelling of electrical power systems.

Outlines

System Modeling

Synchronous machine.

Transformer.

Transmission line.

Cable.

Loads.

System Analysis

Basic stability concepts:

- Nonlinear systems.
- Equilibrium points.
- Stability regions.

Power Flow:

- System model.
- Equations and solution techniques.
- Contingency analysis.

Voltage Stability

Definitions.

Basic concepts:

- Saddle-node bifurcation.
- Limit-induced bifurcation.

Continuation Power Flow (CPF).

Direct methods.

Indices.

Protections and controls.

Real case example: August 2003 North American blackout.

Angle Stability

Definitions.

Small-disturbance:

- Hopf Bifurcations.
- Control and mitigation.
- Practical applications.

Transient Stability (large-disturbance):

- Time domain.
- Direct Methods:
  - Equal Area Criterion.
  - Energy Functions.

Real case example: May 1997 Chilean blackout.

Frequency Stability

Definitions.

Basic concepts.

Protections and controls.

Real case example: September 2003 Italian blackout.

Software Tools

Outlines.

UWPFLOW.

Matlab.

PSAT.

References

P. Kundur, *Power System Stability and Control*, Mc Graw Hill, 1994.

P. Sauer and M. Pai, *Power system dynamics and stability*, Prentice Hall, 1998.

A. R. Bergen and V. Vittal, *Power systems analysis, Second Edition*, Prentice-Hall, 2000.

C. A. Caizares, Editor, *Voltage stability assessment: concepts, practices and tools*, IEEE-PES Power System Stability Subcommittee Special Publication, SP101PSS, May 2003.

P. M. Anderson and A. A. Fouad, *Power system control and stability*, IEEE Press, 1994.

J. Arrillaga and C. P. Arnold, *Computer analysis of power systems*, John Wiley, 1990.

I. S. Duff, A. M. Erisman and J. K. Reid, *Direct Methods for Sparse Matrices*, Oxford Science Publications, 1986.

J. Stoer and R. Bulirsch, *Introduction to Numerical Analysis*, Second Edition, Springer-Verlag, 1993.

M. Ilić and J. Zaborszky, *Dynamics and Control of Large Electric Power Systems*, Wiley, New York, 2000.

C. A. Cañizares, *UWPFLOW*, available at www.power.uwaterloo.ca

F. Milano, *PSAT, Power System Analysis Toolbox*, available at www.power.uwaterloo.ca

Journal papers and technical reports.

Course notes available on line.

Evaluation

Two projects are required.

The projects concentrates in the various topics discussed in class.

These will require the use of MATLAB, PSAT and UWPFLOW (the last two are free software for stability studies co-developed at the University of Waterloo, Canada).

Reproducing examples presented in the slides using UWPFLOW and MATLAB.

Stability analysis of the IEEE 14-bus test system using PSAT.