Industrial Power System Modeling and Simulation Using PSCAD

Date: *November 23 to 25, 2005*
Time: *9:00AM to 5:00PM*
Location: *Korea University, Seoul, Korea*

Instructors:

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General

The workshop is intended for PSCAD users who are somewhat familiar with PSCAD and have industrial experience. However, the users may not be familiar with the modeling and simulation aspects. This course will provide a brief overview of the electromagnetic transient simulation of power systems and discuss application of PSCAD in several industrial applications. The applications discussed will impart real-life experience based on practical examples used in the industries. Simplified example cases discussed in the course will be made available to participants along with the presentation material. Attendees are urged to bring their Laptops loaded with PSCAD (free student edition, professional edition or academic edition) so that they can have hands on experience during the workshop and seek guidance from the instructors.

The topics to be covered in the class are broadly divided into the following daily schedule. Please note that the topics to be covered in day 2 and 3 are many and cover a wide range of applications. It goes without saying that there is not enough time for in-depth coverage. In fact each of the these topics, if covered in detail, is a 3 day course by itself. Several case study example will be shown and salient features of developing the models for these applications will be discussed in class. We will roughly allocate about 30 minutes per topic and allow about 15 minutes of discussion. There will be several hands-on examples that will cover these topics, many of them will be prepared for you.

The **daily schedule** lists the topics in terms of their application. The **detailed outline** lists the modeling aspects that you will learn in the course that can be applied in your own professional studies. Regular coffee breaks and lunch breaks will be scheduled.

Daily Schedule:

Day 1: Introduction to PSCAD

- Installing the software and getting started
- Introduction
- Brief overview of PSCAD/EMTDC
- Simple hands on tutorial to develop a simulation case in PSCAD/EMTDC
- Distinction between electromagnetic transients, power flow and transient simulations
- Short discussion on the fundamentals of electromagnetic transient simulation.
- Designing a module and control component

Day 2: Detailed presentation and discussion of system simulation aspects

- Traditional power system studies
- Large scale system modeling
- Transient performance testing of relays
- Fast bus transfer studies
- Transformer Inrush studies

- Motor starting transient simulation
- Ferro-resonance and effect on protection system

Day 2: System studies continued …

- Transient over voltage studies
- Faults
- Lightening studies
- Capacitor bank switching studies
- Wind system models and interconnection issues
- Synchronous machine and sub-synchronous resonance
- Distributed generation using wind, diesel, PV Cells and Fuel Cell
- Drive modeling
- All electric ships systems

Detailed Outline: What do you learn in the course?

1. What is where in the PSCAD GUI
2. Creating a small simulation case using PSCAD
   - Building the power system
   - Data entry
   - Results, graphs, plots and meters
   - Interactive control features of PSCAD (sliders, push buttons, dials and switches.

3. Fundamental theory of transient simulation
   - Distinction between electromagnetic transients, power flow and transient simulators
   - Representation of different power system components and control system elements in EMTDC
   - Selection of the simulation time step
   - Studies the requires simulation tools like PSCAD
   - Advantages of PSCAD for fast and accurate solutions

4. Brief look at the models and examples available in PSCAD
   - Overview of PSCAD and EMTDC program structure
   - Message tree: errors and warnings, debugging, find feature
   - Overview of help system
   - Keyboard shortcuts, context sensitive help, fly-by help, node help
   - PSCAD and EMTDC manuals

5. Brief introduction to designing custom models in PSCAD
   - Page modules: Node connection, import/export nodes, XNodes
   - Strategy for hierarchical design
   - Control component: Parameters, script
   - Custom Library

6. Creating a more detailed power system to perform transient studies.
   This is based on a typical case designed by the instructor ahead of time.
   - Network equivalences representing remote parts of the network
   - How to decide on the network boundaries and to get the necessary information will be discussed in class.
   - Synchronous machines
   - Transformers
   - Motors
   - Transmission lines (including lines sharing the same right of way)

- Breakers
- Surge arrestors
- Active filters or power electronic devices
- CT, VT and protection equipment

7. We will investigate how to perform typical studies either using cases created in the class or pre-built cases. Most studies require IEEE or other guidelines and these will be listed for the convenience of the user.

8. Initializing the simulation to a load flow condition as determined by the user.
    - Typically, the transient study is performed under a specific load flow condition. We will discuss this and initialize the network accordingly.

9. We will study the key features of performing the following studies
    - Transient over voltage studies: Key features such as **batch mode processing (multiple run)** to capture the worst case, point on wave switching, influence of different parameters will be discussed.
        i. Line energizing (charging and discharging transients)
        ii. Capacitor bank back to back switching, selection of inrush and out-rush reactors,
        iii. Breaker re-strike
        iv. Energy dissipation of surge arrestors, arrestor rating and the selection of arrestors. Surge arrestors are designed based on system TOV studies.

    - Transient recovery voltage across breakers: Key aspects such as need for representing stray capacitances, determination of station stray capacitance values, IEEE breaker capability curves will be discussed.

    - Faults
        i. Preparing the simulation to perform a **sequence** of events such as the occurrence of a fault, breaker opening, fault clearance and re-closure etc.
        ii. DC offset in fault current, the rate of decay and its influence on CT saturation and relay mis-operation.
        iii. Automated generation of a large number of fault waveforms in **COMTRADE** format for real time relay testing.

    - Protection systems
        i. Detailed CT saturation models
        ii. Modeling a simple relay scheme

    - Transformer studies
        i. Inrush current issues
        ii. Saturation
        iii. Representing different core types
        iv. Unbalanced loading and grounding issues

    - Ferro resonance examples
    - Large induction motors starting issues to address flicker and voltage dip problems, stalling, etc.
    - Using power electronic modules and designing simple firing systems
    - Generators
        i. Controls including governors, exciters, PSS, etc.
        ii. Using optimization routine of PSCAD to tune the gain of a PSS.
        iii. Inter area oscillations
        iv. Loss of synchronization and critical clearing times for faults

v. Effect of exciter gain on stability
vi. Load sharing and tie line power

- Using PSCAD to determine the network impedance profile at different buses. This can be used to identify many potential problems in the network such as sub synchronous resonance issues, harmonic voltage distortion issues, filtering issues etc. These will be discussed in class with simple illustrative examples.
- Sub synchronous resonance studies
  i. Series compensated lines
  ii. Used of the network frequency scan model to identify possible problems
  iii. Representing the turbine-generator mechanical system for SSR studies
  iv. Induction generator effect of the synchronous machine and voltage amplification
  v. SSR torsional interaction of their shaft.

- Distributed generation
  i. A wind farm example or any other as requested by the users. The model of the wind farm will cover details such as turbine pitch control, doubly fed induction machine controls etc. The models will be suitably simplified so that the users will understand the concept easily yet will contain essential details.
- Typical distribution system studies
  i. Power quality (harmonics, filters, DVR, voltage sags, resonance, flicker etc.)
  ii. Grounding
  iii. Islanding of customers stand-alone generators