EL 6633 – Transients, Surges and Faults in Power Systems

By: Francisco de Leon Spring 2010

Thursdays from 6:00 to 8:40

Objective: At the end of the term the participants will be able to compute and analyze the most common electrical transients that a power system is subjected. This course relies on the use of an electromagnetic transients simulation program such as the ATP, EMTP-RV or PSCAD. A great number of application examples will be resolved in class, as assignments and as projects.

Syllabus: A refresher of basic concepts of electric circuits and its elements. Classification and importance of the study of electromagnetic transients in power systems. Switching transients in simple electrical circuits. Mathematical tools: analytical and numerical solution of differential equations. Computational tools: the EMTP and ATP. Normal and abnormal switching transients, faults and lightning. Transients in three-phase circuits. Transients in transmission lines, transformers, machines, inductors, capacitors, etc. Introduction to the modeling of power apparatus and system components. Case studies. Protection against and reduction of the effects of electrical transients (overvoltages and overcurrents).

Textbook: Allan Greenwood, "Electrical Transients in Power Systems", Second Edition, John Wiley & Sons, 1991. ISBN: 0-471-62058-0.

Additional Information: Access to the royalty free ATP will be provided to those who complete the licensing agreement with the Canadian/American EMTP User Group at http://www.emtp.org/. Students are invited to bring their laptops to work (hands-on) the class examples. Note however, that the course is about transients and not about using the ATP. The EMTP Theory book and the ATP Draw Users Guide will be provided as pdf files.

Course Evaluation:

Mid-term exam:	30%
Project + Presentation:	30%
Final exam:	40%

Class Schedule

Lectures: 1/21, 1/28, 2/4, 2/11, 2/18, 2/25, 3/11, 3/25, 4/1, 4/8, 4/15, 4/22
Midterm: 3/4
Projects due + presentations: 4/28
Final: 5/1

Detailed Contents

1. **Electric Circuits: A Refresher**
    a. Current and voltage sources
    b. Resistance, inductance (self and mutual) and capacitance
    c. Series and parallel circuits
    d. Classification of electromagnetic transients in power systems
        i. Over-voltages and over-currents
        ii. By device: transmission lines, transformers, capacitors, motors.
    e. Simple transients
        i. RL and RC circuits
        ii. Introduction to solution methods
        iii. Special circuits with mathematical contradictions
        iv. RLC Circuit
    f. ATP examples

2. **Numerical Tools**
    a. Numerical integration
    b. Trapezoidal rule of integration (TRI)
        i. Absolute stability
        ii. Numerical oscillations
    c. Norton equivalent circuits
    d. KCL and KVL

3. **Simulation Tools**
    a. Time-domain solution of the state equations
    b. EMTP/ATP
    c. Comparison of analytical and ATP solutions
    d. Special circuits with mathematical contradictions
    e. Numerical oscillations of TRI

4. **Modeling of Power Apparatus and Systems**
    a. Transmission lines
    b. Cables
    c. Transformers
    d. Generators
    e. Switchgear
    f. Surge arresters

5. **Normal and Abnormal Switching Transients**
    a. Connection and disconnection of transmission lines
    b. Connection and disconnection of transformers and inductors
    c. Connection and disconnection of capacitors
    d. Symmetrical and asymmetrical faults
    e. Transient recovery voltage

6. Transients in Three-Phase Systems
   a. Symmetrical components
   b. Modal transformations
   c. Connection of lines, transformers, capacitors and faults

7. Faults
   a. Three-phase fault
   b. Single-phase to ground fault
   c. Calculation methods

8. Lightning
   a. Description of the problem
   b. Physical phenomena
   c. Effects in the power system
   d. Impulse test

9. Protection and Reduction of Transients
   a. Shielding
   b. Arresters
   c. Grounding
   d. Circuit elements
   e. Insulation coordination

10. Advanced Topics
   a. Calculation of model parameters
   b. Electric equivalents of magnetic circuits
   c. Frequency dependency
   d. Modeling of non-linear components