**ELEN 4250**: **Transients in Electric Energy Systems and Devices**

**Class Schedule:** 3 credit hours

**Course Coordinator**: Nabeel A. O. Demerdash

**Course Materials:**

**Required:** Class Notes, by Course Instructor, Dr. N.A.O. Demerdash

**Course Description:** Covers microsecond fast transients in power systems and devices resulting from lightning strokes, switching surges in power systems and devices, as well as impulse surges resulting from pulse width modulation in modern adjustable speed drives, using distributed parameter models and analysis of transmission lines and windings of transformers, generators and motors. Also covers successive reflections, transition points, wavefront flattening techniques and surge arrestor design applications for voltage buildup reduction and control are studied. Includes polyphase multivelocity multi-conductor system transients.

**Prerequisites:** ELEN 2020 and ELEN 3110

**Selected Elective** in Power and Energy Systems area.

**Contribution to Professional Component:**

Engineering Science 40%

Engineering Design 60%

**Course Goals:**

Gives the student the skills to design surge suppression systems to protect electric energy equipment against microsecond type electrical impulse/surge phenomena, under successive reflection and transition point conditions. Distributed parameter modeling and analysis skills will be covered. These skills have also gained additional importance with the wide use of pulse width modulation techniques in the ever expanding industrial use of adjustable speed drives, and electronic power conditioning impact in renewable energy systems.

Design experience with wavefront flattening techniques for energy devices and energy systems using distributed parameter methods of analysis. Design of proper surge arrester systems to protect transformers, busbars, motors and generators in transmission system design. Design experience in minimization of successive surge/wave reflection in interconnected energy systems. Insulation coordination design considerations, shielding and insulation system design for reduction of turn-to-turn electric stresses in windings of transformers, generators and motors, under lightning and switching surge conditions. Examination of design considerations of motor windings, in relation to pulse width modulation problems associated with motor winding stresses in modern power electronically controlled adjustable speed drivers and renewable electric energy generation systems, for moderate and high kHz operating pulse/carrier frequencies.

**Course Objectives:**

*By the end of this course, the student should be able to..*

1. Analyze and simulate electrical transients in lumped parameter models of polyphase and single phase power systems.
2. Analyze and simulate electrical transients and surges in distributed parameter (wave equation) models of polyphase and single phase (multi-conductor and single conductor) power transmission, distribution and utilization systems.
3. Design lighting and surge protection schemes and devices to protect power equipment in legacy and renewable energy transmission and utilization equipment in power systems.
4. Design wave flattening and surge suppression means in pulse width modulated motor-adjustable speed drive systems with PWM carrier frequencies in the multi kHz range and in other renewable energy generation systems involving power electronic switching.
5. Simulate by computer-aided means, complex electric surges in motors, generators, transformers, and transmission lines, and design schemes to keep such surge magnitudes to any required minimum values.

**Contribution to Program Objectives:** partial fulfillment of Criterion 3 objectives A, B, C, E, G, I, K

**Course Topic:**

1. Introduction to Transients in Single Phase and Three Phase Power Circuits

2. Power Transmission Line Distributed Parameter Modeling - The Wave Equation in the Time-Domain

3. Travelling Waves - Lossless and Lossy Power Lines in the Time-Domain

4. Transition Points and Successive Reflections in the Time-Domain

5. Lighting and Surge Protection, and Comparison to PWM Voltages in Adjustable Speed Drives

6. Travelling Waves on Multi-Conductor Power Systems - Multi-Velocity Formulations in the Time-Domain

7. Behavior of Windings of Electric Power Devices Under Surge Conditions - Transformers, Motors and Generators

8. Motor Winding Surges in Adjustable Speed Drives with Pulse Width Modulation

9. Advanced Concepts and Computer-Aided Modelling of Switching Surges in Power Systems

Last modified: January 24, 2018