EECE 187
May 2000

EECE 187: Electrical Transients and Surges in Power Systems and Devices

Course Description:
The study of 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. Successive reflections, transition points, wavefront flattening techniques and surge arrestor design applications for voltage buildup reduction and control are studied. Polyphase multi-velocity multi-conductors system transients are included.

Prerequisites: EECE 012 and EECE 121 or equivalents

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

Course Goals:

Gives the student the skills to design surge suppression systems to protect electric power 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.

Design experience with wavefront flattening techniques for power devices and power 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 power 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, for moderate and high kHz operating pulse/carrier frequencies.

Course Objectives:
By the end of this course, the student should..

- Be able to analyze and simulate electrical transients in lumped parameter models of polyphase and single phase power systems.
- Be able to 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.
- Be able to design lighting and surge protection schemes and devices to protect power equipment in energy transmission and utilization equipment in power systems.
- Be able to 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.

- Be able to 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.

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

Contribution to Professional Component: Engineering Science 40%
Engineering Design 60%

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

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Course Coordinator: Nabeel A. O. Demerdash

Last modified: July 13, 2000

EECE 187: Electrical Transients and Surges in Power Systems and Devices
ABET Objectives, Assessment Instruments,
and Assessment Criteria

(A) An ability to apply knowledge of mathematics, science, and engineering.
Demonstrated competence in prerequisite course work when applied to EECE 187.

from EECE 121	Understanding electric and magnetic fields, and in particular Gauss' law, capacitance, dielectrics, and Ampere's law, Biout-Savart law, magnetic materials and concepts of flux, flux density, flux linkage, energy and inductance/capacitance, in the presence of magnetic materials/dielectric materials.
from EECE 012	Understanding of sinusoidal steady state electric circuit analysis with phasors, including three-phase balanced circuits, as well as computation of real and reactive power and power factor.

Tests and homework will demonstrate competence in most areas. Computer simulation of electrical transients in power systems using FORTRAN or another high level language in a project will demonstrate competence in the use of numerical methods. Minimum competence in test, homework and project depends on the student's relative standing in the class with a grade dependent on the overall score distribution.

(B) An ability to design and conduct experiments, as well as to analyze and interpret data.
Simulation project of transients, with students working in teams

(C) An ability to design a system to meet desired needs.
A design components in the homeworks and projects - See (B).

(E) An ability to identify, formulate, and solve engineering problems.
Demonstrate competence in course material by solving assigned homework from notes as supplied by instructor. Tests and homework will demonstrate such competence, with minimum competence defined as given above in (A).

(G) An ability to communicate effectively.
Demonstrate competence in communicating qualitative explanations of various performance phenomena and characteristics in electric power systems and devices.

(I) The recognition of the need for and ability to engage in life-long learning.
Demonstrate awareness of recent developments and possible future trends in the state of the art of surge protection, flattening and suppression as reported in professional society publications dealing with such aspects.

(K) An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
Complex simulation project will introduce students to a variety of such tools.

(L) An ability to apply probability and statistics and higher mathematics to the solution of

engineering problems.
See (K) above.

Evaluation of Objective Attainment - Continuing Course Review with appropriate reporting of feedback from instructors to course coordinator and the Undergraduate Committee.

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