NORTH CAROLINA STATE UNIVERSITY
ELECTRICAL AND COMPUTER ENGINEERING

ECE 587: Power System Transients Analysis
Fall 2024

Instructor: Dr. Leonard White, PE
Email: lwwhite@ncsu.edu
Office hours: Office meetings and/or *Zoom* calls available by arrangement.

Class Lectures: In-class presentation. Lectures are scheduled in Monteith Research Center (MRC), Room 136, 16:30 – 17:45, Mondays and Wednesdays between August 19, 2024 and December 3, 2024.

Prerequisites: ECE 451 or equivalent

Credit Hours: 3 Hours

Course Description:

Review of solutions to first and second order differential equation for electric power circuit transients. Computer solution techniques for transient analysis using *PSCad* and *Matlab/Simulink*. Applications to fault current, shunt capacitor switching, circuit switching overvoltage and transformer transient behavior analysis. Distributed line modeling for traveling wave analysis of surge events. Introduction to voltage insulation, surge arrestor operation and lightning stroke analysis. Modeling of utility power electronics circuits including single and three-phase rectifiers and inverters. Control systems principles for Distributed Energy Resources (DER) interfaces. Applications for distributed generation, photovoltaic systems, battery energy storage with emphasis on microgrid operation.

Student Learning Outcomes:

- Define what differentiates power system transient analysis from power system steady-state analysis for transmission and distribution circuits.
- Derive and solve the basic first and second order differential equations associated with common fault and switching events such as short circuits, capacitor switching, inductor switching, capacitor restrike, and transformer energization.
- Perform transient analysis of common fault and switching events using an electromagnetic transients simulation program (*PSCad*).
- Derive surge voltages and currents associated with lightning strikes and switching on transmission lines using traveling wave analysis.
- Derive relationships that determine inrush and fault characteristics for motors and generators as may be encountered in normal operations of rotating machinery.
- Derive operating voltages and currents associated with power electronic devices that interface with the electric grid such as rectifiers, inverters and motor drives.
- Investigate harmonic content of waveforms generated by the introduction of solid-state devices into the power system; develop relationships for powers as related to harmonic content.
- Develop models of control systems for DER systems such as may be used in distributed synchronous generation, photovoltaic electric system, energy storage.
- Be able to develop simulations of microgrid systems consisting of a mix of DER devices.

References:

Allan Greenwood, *Electrical Transients in Power Systems*, John Wiley, 1991. (Copied chapters in reserve)

Lou van der Sluis, *Transients in Power Systems*, Wiley, 2002. (eBook)

Arieh L. Shenkman, *Transient Analysis of Electric Power Circuits Handbook*, 2005. (eBook)

Mahmoud Nahvi and Joseph Edminister, *Schaum's Outline of Electric Circuits*, 6th Edition, 2013. (eBook)

Grading:

Homework	20%
Mid-Term Exam	30%
Final Exam	50%

Homework:

Homework assignments and solutions will be posted on the course *Moodle* site. Late homework will be accepted for 24 hours after the due date/time for 90% credit. No credit will be available after the solutions are posted. Students should utilize course *Moodle* forums for online questions regarding homework/exams instead of sending emails directly to the instructors; use personal email for any unusual circumstances that may arise during the semester.

Exams:

A mid-term exam and final exam will be administered to the class. Only the University approved reasons will be accepted for missing an exam.

(See http://www.ncsu.edu/policies/academic_affairs/pols_regs/REG205.00.4.php).

A make-up exam will be administered at the mutual convenience of the student and the instructor. In all cases, signed documentation must be provided to the instructor and attached to the make-up exam in order to obtain credit. The Mid-term and the Final Examination will be take-home exams, open book, open notes, open Internet and any material permitted except another person or group of persons.

Academic Integrity:

Work in this course is to be done under the Academic Integrity Honor Pledge:

"I have neither given nor received unauthorized aid on this test or assignment."

Students must abide by the Code of Student Conduct articulated at:

http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php

Evidence of copying, including copying of source code, or any other use of unauthorized aid will be investigated and potentially referred to the University judicial system as a violation of the **Code of Student Conduct**. The *minimum sanction* for a violation is a zero on an assignment. Recycling of projects from another resource will be considered an academic integrity violation.

Students with Disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, (919) 515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG 02.20.01).

N.C. State University Policies, Regulations, and Rules (PRR):

Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include:

http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement)

http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity)

http://policies.ncsu.edu/policy/pol-11-35-01 (Code of Student Conduct)

http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average).