Fall 2023

ECE 613 - PROTECTION OF POWER SYSTEMS

Josh Taylor

Syllabus

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Faculty Contact Information

Instructor: Josh Taylor

Email: jat94@njit.edu

Office Hours: Fridays at 9am, on Zoom

Textbook and Materials

Horowitz, S., Phadke, A., & Niemira, J. *Power System Relaying*. Wiley, 4th edition, 2014, ISBN: 978-1118662007.

References:

The material covering symmetrical and unsymmetrical fault calculations can be found in many power system analysis books including reference 1 and 2. Homework problems related to those topics are assigned from reference 1. That reference will be referred to as Ref 1.

1. Glover, J., Sarma, M., & Overbye, T. *Power System Analysis and Design.* Cengage Learning, 5th edition, 2011, ISBN 978-1111425777. (This reference refers to the PowerWorld software extensively [see below under software].)

2. Grainger, J., & Stevenson, W. *Power System Analysis.* McGraw-Hill, 1st edition, 1994, ISBN 978-0070612938.

3. The following reference is often used as a textbook on the subject: Blackburn, J., & Domin, T. *Protective Relaying: Principles and Applications*. CRC Press, 2nd edition, 1997, ISBN 978-0824799182.

4. *Network Protection & Automation Guide*. ALSTOM, 2002, ISBN 978-2951858909. (A valuable reference available for free download from **Alstom website (http://www.alstom.com/grid/products-and-services/Substation-automation-system/protection-relays/Network-Protection-Automation-Guide-NEW-2011-Edition/)** and other locations, for e.,

https://rpa.energy.mn/wp-content/uploads/2016/07/network-protection-and-automation-guide-book.pdf.)

Assignment Policies

Total points earned for homework assignments will be normalized so that the maximum possible points is 25 points out of 100 for the course. The assignments will remain available one week after the due date. However, 15% of the grade will be deducted for each day delay. The assignments are to be uploaded to Canvas.

Student Conduct

The NJIT University code on academic integrity, found at, **http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf (http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf)** will be followed in all courses.

"Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf (http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf) .

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. ***Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.*** *If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at* ***dos@njit.edu (mailto:dos@njit.edu)*** *"*

Grading Scale

Grade	GPA	Percentage
A	4.0	90–100%
B+	3.5	80–89.99%
B	3.0	70–79.99%
C+	2.5	60–69.99%

C	2.0	50–59.99%
F	N/A	0–49.99%

Grading Categories

Categories	Points
Homework Assignments	25
Midterm Exam	35
Final Exam	40

Course Structure

Module	Content	Dates
1.	Introduction to Protective Relaying 1.1 What is Relaying? 1.2 Power System Structural Considerations Review: the Y-matrix, MATLAB functions	September 6 - September 11
2.	Elements of a Protection System 1.3 Power System Bus Configurations 1.4 The Nature of Relaying 1.5 Elements of a Protection System 1.6 International Practices	September 12- September 18
3.	Symmetrical Faults	September 19 - September 25

4.	Symmetrical Components and Unsymmetrical Faults	September 25 - October 2
5.	Relay Operating Principles 2.1 Introduction 2.2 Detection of Faults 2.3 Relay Designs 2.4 Electromechanical Relays 2.5 Solid-State Relays 2.6 Computer Relays 2.7 Other Relay Design Considerations 2.8 Control Circuits: A Beginning	October 3 - October 9
6.	Current and Voltage Transformers 3.1 Introduction 3.2 Steady-State Performance of Current Transformers 3.3 Transient Performance of Current Transformers 3.4 Special Connections of Current Transformers 3.5 Linear Couplers and Electronic Current Transformers 3.6 Voltage Transformers 3.7 Coupling Capacitor Voltage Transformers 3.8 Transient Performance of CCVTs 3.9 Electronic Voltage Transformers	October 10 - October 16

7.	Midterm Exam	Tuesday, October 17 6:00 PM EST
8.	Nonpilot Overcurrent Protection of Transmission Lines 4.1 Introduction 4.2 Fuses, Sectionalizers, and Reclosers 4.3 Inverse, Time-Delay Overcurrent Relays 4.4 Instantaneous Overcurrent Relays 4.5 Directional Overcurrent Relays 4.6 Polarizing	October 24 - October 30
9.	Nonpilot Distance Protection of Transmission Lines 5.1 Introduction 5.2 Stepped Distance Protection 5.3 R–X Diagram 5.4 Three-Phase Distance Relays 5.5 Distance Relay Types 5.6 Relay Operation with Zero Voltage 5.7 Polyphase Relays 5.8 Relays for Multiterminal Lines 5.9 Protection of Parallel Lines 5.10 Effect of Transmission Line Compensation Devices 5.11 Loadability of Relays	October 31-November 6

10.	Pilot Protection of Transmission Lines 6.1 Introduction 6.2 Communication Channels 6.3 Tripping Versus Blocking 6.4 Directional Comparison Blocking 6.5 Directional Comparison Unblocking 6.6 Underreaching Transfer Trip 6.7 Permissive Overreaching Transfer Trip 6.8 Permissive Underreaching Transfer Trip 6.9 Phase Comparison Relaying 6.10 Current Differential 6.11 Pilot Wire Relaying 6.12 Multiterminal Lines 6.13 The Smart Grid	November 7 - November 13
11.	Rotating Machinery Protection 7.1 Introduction 7.2 Stator Faults 7.3 Rotor Faults 7.4 Unbalanced Currents 7.5 Overload 7.6 Overspeed 7.7 Abnormal Voltages and Frequencies 7.8 Loss of Excitation 7.9 Loss of Synchronism 7.10 Power Plant Auxiliary System	November 14- November 20

	7.11 Winding Connections 7.12 Startup and Motoring 7.13 Inadvertent Energization 7.14 Torsional Vibration 7.15 Sequential Tripping	
12.	Transformer Protection 8.1 Introduction 8.2 Overcurrent Protection 8.3 Percentage Differential Protection 8.4 Causes of False Differential Currents 8.5 Supervised Differential Relays 8.6 Three-Phase Transformer Protection 8.7 Volts-per-Hertz Protection 8.8 Nonelectrical Protection 8.9 Protection Systems for Transformers	November 21 - November 27
13.	Bus, Reactor, and Capacitor Protection 9.1 Introduction to Bus Protection 9.2 Overcurrent Relays 9.3 Percentage Differential Relays 9.4 High-Impedance Voltage Relays 9.5 Moderately High-Impedance Relay 9.6 Linear Couplers 9.7 Directional Comparison 9.8 Partial Differential Protection 9.9 Introduction to Shunt Reactor	November 28 -December 4

	Protection 9.10 Dry-Type Reactors 9.11 Oil-Immersed Reactors 9.12 Introduction to Shunt Capacitor Bank Protection 9.13 Static Var Compensator Protection 9.14 Static Compensator	
14.	Switching Schemes and Procedures 12.1 Introduction 12.2 Relay Testing 12.3 Computer Programs for Relay Setting 12.4 Breaker Failure Relaying 12.5 Reclosing 12.6 Single-Phase Operation	December 5 - December 11
15.	Surveys and Final Examination	December 12 - December 18

Time Commitment

This course is a three credit-hours course. Assuming the average load of a full-time student is 15 credit-hours, and assuming a full-time student works 45 hours/week towards his/her studies, then this course requires 9 hours of study and class time per week on the average.

Discussion Board Criteria

We will provide a discussion forum on the course website for all students of ECE613. You may use these forums to discuss course concepts, problem solving methods, interesting learning resources, or anything else that may be of interest. You may just use the forum to ask questions. Please be brief and courteous when posting.

Late Work and Make-Up Exams

Homework are due on Sundays. 10% of the grade will be deducted for each day the assignment is late.

No make-up exams.

Student with Disabilities

NJIT adheres to section 504 of the Rehabilitation Act (ADA) of 1990. Appropriate accommodations are provided at no cost to the student. If you have any questions or would like additional information, please contact Dr. Phyllis Bolling, Center for Counseling and Psychological Services (C-CAPS), Campbell Hall, (entry level), room 205, (973) 596-3420. For further information, visit the **Student Disability Services (http://www5.njit.edu/studentsuccess/disability-support-services-0/)** website.

Technical Support

For assistance with the following items, please contact NJIT IST Helpdesk at: **1-973-596-2900 (tel:1-973-596-2900)** or **http://ist.njit.edu/support/helpdesk.php (http://ist.njit.edu/support/helpdesk.php)**

Software and Hardware Requirements

You will need to install the PowerWorld software for this course.

- PowerWorld offers a demo/educational version of their software that you can use for calculating fault currents at **http://www.powerworld.com/download-purchase/demo-software (http://www.powerworld.com/download-purchase/demo-software)**
  Note: PowerWorld Simulator runs on Microsoft Windows operating systems 2003/XP and newer (both server and client versions, 32-bit and 64-bit editions). No other operating systems are supported.
