Lahore University of Management Sciences

EE453 – Power System Protection and Stability Fall 2015-16

Instructor	Mashood Nasir
Room No.	Power Lab
Office Hours	Tuesday Thursday 11:00am – 1:00pm
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TA	Umer Irfan
TA Office Hours	Friday 10:00 -12:00
Course URL (if any)	https://goo.gl/TXmWNQ

Course Basics				
Credit Hours	3			
Lecture(s)	No. of Lectures Per Week	2	Duration	75 min each
Recitation/Lab (per week)	No. of Lectures Per Week	As needed	Duration	
Tutorial (per week)	No. of Lectures Per Week	As needed	Duration	

Course Distribution	
Core	N
Elective	Y
Open for Student Category	All
Close for Student Category	None

Course Description

This course is intended to provide the basic theory, principles and practices of power system protection and stability. Techniques to analyze a power system under various symmetrical and unsymmetrical fault conditions will be covered. Different relaying schemes will be discussed for overcurrent, differential and distance protections. The applications of these relays will be explored in the protection of transformers, bus-bars, rotating electrical machines and transmission lines. Abnormal conditions and disturbances that may cause steady state and transient stability issues in power systems will also be evaluated.

Course Prerequisite

• EE 353	Electrical Power Systems

Course Objectives

This course is aimed to provide the students a detailed understanding of the

- Techniques for symmetrical and unsymmetrical fault analysis.
- Protective relaying schemes, fuses, circuit breakers and their co-ordination.
- Techniques for steady state and transient stability analysis.

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Course Learning Outcomes	
CLO1:	• Analysis of a power system under all possible fault scenarios and determine the appropriate ratings of circuit breakers to clear those faults.
CLO2:	• Determination of the role of current and voltage transformers in power system protection.
CLO3:	• Application of non-directional and directional overcurrent relays, definite time overcurrent and inverse time over current relays
CLO4:	• Application of differential and percentage differential protection for transformers and bus bars
CLO5:	• Implement Distance relays including Impedance , reactance and Mho relays for the protection of Transmission Lines
CLO6:	• Application and analysis of different protection schemes in industrial power plants
CLO7:	• Analysis of the major disturbances and stability issues related to the faulty and abnormal conditions in power systems

Relation to EE Program Outcomes			
CLOs	Related PLOs	Teaching Method	CLO Attainment checked in
CLO1:	PLO1	Instruction, Assignments	Midterm, Final
CLO2:	PLO1	Instruction, Assignments	Midterm, Final
CLO3:	PLO2	Instruction, Assignments	Midterm, Final
CLO4:	PLO2	Instruction, Assignments	Midterm, Final
CLO5:	PLO2	Instruction, Assignments	Midterm, Final
CLO6:	PLO2	Instruction, Assignments	Midterm, Final
CLO7:	PLO2	Instruction, Assignments	Midterm, Final

Grading Breakup and Policy
• Assignments (Computing + Simulation): 10% • Quiz(s): 15% • Midterm Examination: 30% • Semester Project: 10% • Final Examination: 35%

Examination Details	
• Mid Term	Yes/No: Yes Combine/Separate: Combined Duration: 02 hours Exam Specifications: closed book, closed notes, calculators
• End Term	Yes/No: Yes Combine/Separate: Combined Duration: 03 hours Exam Specifications: closed book, closed notes, calculators

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Lecture Plan		
Lecture	Topics	Recommended Readings
1	**Overview** Overview of electric power systems, One line diagrams, per unit quantities and types of faults	Glover : Chapter 3 Stevenson: Chapter 2
2-3	**Symmetrical Fault Analysis** Balanced three phase faults, Short circuit capacity and selection of circuit breakers.	Glover : Chapter 7 Stevenson: Chapter 10 Hadi-Saadat: Chapter 9
4-6	**Unsymmetrical Fault Analysis** Symmetrical Components and sequence networks, Zero, positive and negative impedance circuits of transmission lines, generators and motors. Unbalanced Fault Analysis Using Symmetrical Components	Glover : Chapter 8 Stevenson: Chapter 11 Hadi-Saadat: Chapter 10
7-8	**Intro to Protective Relaying and Operating Principles of Relays** Power system structural considerations and bus configurations, nature of relaying and elements of power protection, Operating principles and types of relays, Overview of electromechanical relays, solid state relays and computer relays.	Horowitz: Chapter 2
9	**Operating Principles and Types of Circuit breakers and Fuses** Principles and methods of Arc extinction, Classification of circuit breakers, Types of Fuses, Current Capacity of Fuses, Difference between a fuse and circuit breaker.	V.K.Mehta: Chapter 19 and 20
10-11	**System Transducers and Instrument Transformers** Working principles of Current Transformers (CT), Potential transformers (PT) and Coupled Capacitor Voltage Transformers (CCVT). Steady state and transient performance of Current transformers and voltage transformers.	Horowitz : Chapter 3
12-14	**Over-Current Protection of Transmission Lines** Instantaneous overcurrent relays, Definite time-delay overcurrent relays, Inverse, time-delay overcurrent relays, Directional overcurrent relays, Reverse power relay and drawbacks of over current relays	Horowitz : Chapter 4 Paithankar : Chapter 2
15	**Simulink/MATLAB based Modeling** Modeling of over current relays	Handouts will be uploaded on LMS
16	**Mid Term**	
17-19	**Distance Protection of Transmission Lines** Operational characteristics and R-X diagrams of Simple impedance relay, reactance relay and MHO relay. Protection of parallel lines	Horowitz : Chapter 5 Paithankar : Chapter 6

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20-22	**Differential and Over Current protection of Transformers** Types of faults on transformer, Over current protection, Percentage Differential of Transformer, Inter turn faults on Transformers, Incipient Faults on Transformers, Buchholz Relay, Volts per Hertz protection **Simulink/MATLAB based Modeling** Differential Protection for Power Transformer	Horowitz : Chapter 8 Paithankar : Chapter 4
23-24	**Busbar Protection** Differential protection of busbars, Stability Ratio of high impedance bus bar differential scheme, Protection of three phase bus bar	Horowitz : Chapter 8 Paithankar : Chapter 5
25-26	**Rotating Machinery Protection** Protection against Stator Faults, Rotor Faults, Unbalanced Currents, Over load, Over Speed, Abnormal Voltages and Frequency, Loss of Excitation, Loss of Synchronism	Horowitz : Chapter 7 Paithankar : Chapter 8 and 9
27-29	**Steady State Stability and Transient Stability** Introduction to steady state and transient stability problem, Rotor dynamics and swing equation, Power - angle equation , Transient stability analysis based on equal Area Criterion and its application	Hadi Saadat : Chapter 11 Stevenson: Chapter 16
Final Term		

Text Books/ Supplementary Readings/ Reference Books	
• Text Books	• Power System Relaying by Stanley H. Horowitz and Arun G. Phadke, John Wiley & Sons, Third Edition, 2008. • Power System Analysis second edition by Hadi. Saadat, McGraw-Hill 2009
• Reference Books	• Power System Analysis and Design by J. D. Glover, M. S. Sarma and T. J Overbye, fourth edition, Thomson Learning, 2008. • Power System Analysis by J. J. Grainger and W. D. Stevenson, Second Edition, McGraw Hill, 2003. • Fundamentals of Power System Protection by Y.G. Paithankar and S.R. Bhide, Prentice Hall, 2010. • Principles of power system by Mehta, V. K., and Rohit Mehta. S. Chand, 1982.