Lahore University of Management Sciences
EE553- High Voltage Engineering
Spring 2018

Instructor	Muhammad Iqbal Qureshi, PhD.
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TA Office Hours	TBD
Course URL (if any)	TBD

Course Basics				
Credit Hours	3			
Lecture(s)	No. of Lectures/Week	2	Duration	75 minutes
Lab (s)	(Per semester)	4	Duration	2 hrs, 30 min each
Tutorial	(On alternate weeks)	1	Duration	75 minutes

Course Distribution	
Core	No
Elective	Yes
Open for Student Category	Electrical Engineering, Physics
Close for Student Category	

COURSE DESCRIPTION

To meet large demands of electrical energy, high and extra high voltage transmission lines and substations are used. Consequently, high voltage apparatus is the backbone of all modern power system networks. Hence, a thorough knowledge of fundamental components of such networks is essential for their optimal design as well as their pre- and post-installation testing and reliable operation.

This course describes the concepts of High Voltage Engineering which are utilized practically in the field. Special emphasis is applied on various insulation materials and their usage in different power equipment. Gas, Liquid and solid insulators with their withstand capability against High voltage surges and stresses. Concept of Transient voltage generation, operation and limitations of Impulse generator etc. Non-destructive test techniques essential for High voltage Engineering will be covered. Relevant research areas will be highlighted which may be adopted on later research. Real practical examples from field will also be the part of curriculum. Suitable experiments will also be conducted at a high voltage laboratory to understand salient features of studied material.

COURSE PREREQUISITE(S)

EE	• Power System Analysis

COURSE OBJECTIVES

1.	Study the importance of high voltage techniques on electrical power networks.
2.	Study the impact of over-voltages on various insulating materials.
3.	Homogenous and heterogeneous electrode systems will be studied.
4.	Different methods of generation of AC, DC and Impulse Test Voltages will be taken into account.
5.	High voltage testing techniques and proof testing of HV equipment will be discussed.

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Learning Outcomes	
CLO1: CLO2: CLO3: CLO4:	Student will be able to understand the importance of High Voltages on Electrical Power system. Learn the principles governing operation, characterization of ideal and non-ideal systems with precautions. Understand the principles of different types of insulations with respect to voltage levels. Applications of different types of circuit breakers, surge arrestors , high voltage cables and line insulators. Innovation will be extracted from selected research papers.

Grading Breakup and Policy	
Assignment(s): (**3**)	10%
Quiz(s): (**4-5) [drop1]**	10% (announced and surprised)
Midterm Examination:	25%
Experimental work: [4 labs]	13% (In addition 2-3 visits to industries related to High Voltage, attendance grades 2%)
Final Examination:	40%
Class Participation: N/A	
Attendance: N/A	

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: N/A Duration: 90 minutes Preferred Date: N/A Exam Specifications: Closed book, closed notes, A4 size sheets, calculator
Final Exam	Yes/No: Yes Combine Separate: N/A Duration: 180 minutes Exam Specifications: Closed books, closed notes, A4 size sheets, calculator

COURSE OVERVIEW

Week #	Topics	Recommended Readings	Related CLOs
1.	• **Introduction to Basic concepts of High Voltage Engineering.** • **High Voltage AC/DC power networks, worldwide scenario.** • **Impact of transient over-voltages on T/L.** • **Generation of testing DC/AC and VLF voltages.**	➢ **General Introduction from Internet** ➢ **E. Kuffle, W.S. Zaengl & J.Kuffle Chapter 1-2**	**CLO1**
2.	• **Principles of single and multiple stage impulse generators** • **Potential dividers** • **(Assignment # 1)**	➢ **E. Kuffle, W.S. Zaengl & J.Kuffle Chapter 1-2**	**CLO1**
3.	• **Principles of High Voltage measurements.** • **Sphere spark gaps. Rod gaps** • **Electrostatic voltmeter, peak voltmeter, voltage transformers** • **Generation and measurement of impulse currents and fast rising current pulses.**	➢ **E. Kuffle, W.S. Zaengl & J.Kuffle Chapter 3** ➢ **E.Kuffle & M.Abdullah**	**CLO2**
4.	• **High voltage insulating materials, their basic properties** • **Classification of insulating materials and their life controlling parameters**	➢ **Internet**	**CLO2**
5.	• **Electric breakdown in gases. Townsend's and Streamer theories, Pashen's law** • **Corona discharges.**	➢ **E.Kuffle & M.Abdullah Chapter 5** **Lucas**	**CLO2**

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	• Breakdown in non-uniform electrode gap		
6.	• Air insulation and influence of atmospheric parameters • Undesirable effects of Corona • (Assignment # 2)	➢ E.Kuffle & M.Abdullah Chapter 5	CLO2
7.	• Liquid insulation • Classification of liquids and role of moisture in oils • Breakdown in insulating liquids. • Solid insulating materials • Classification of solids • Breakdown theories • Treeing and breakdown in practical solid insulation	➢ E.Kuffle & M.Abdullah Chapter 3 ➢ Research papers ➢ Lucas	CLO2, CLO3, CLO4
8.	• (Assignment # 3):-(High Voltage Apparatus • T/F and generators • Bushings and cable terminations • HV capacitors) ***Mid Term Examination***	➢ Internet Handouts	CLO3
9.	• Polymeric insulators • High voltage circuit breakers • SF 6, VCBs • Limitations of CBs and their merits and demerits • GI switch gears	➢ Internet Handouts	CLO2, CLO3, CLO4
10.	• HV Cable materials • HV Cable extrusion processes	➢ Internet ➢ Research papers ➢ Provided handouts	CLO3, CLO4
11.	• Lightening phenomena • Lightening surges • Statistical characteristics of over voltages • Insulation coordination	➢ E. Kuffle, W.S. Zaengl , ➢ Lucas ➢ Handouts	CLO2, CLO3
12.	• Proof testing of insulation levels • V_{50} and σ • High voltage testing • Classifications, procedures and standards • PD testing of rotating m/c, cables, GIS, distribution T/Fs and cables	➢ Internet ➢ Research papers ➢ Handouts	CLO3, CLO4
13/14	• Experiments at high voltage laboratory	➢ Lab handouts	CLO1, CLO2, CLO3, CLO4
15.	***Final Examination***		

Textbook(s)/Supplementary Readings

- **Textbooks:-**

(A) High Voltage Engineering Fundamentals by E. Kuffle, W.S. Zaengl & J. Kuffle, 2000
(B) High Voltage Engineering by E. Kuffle & M. Abdullah, Pergamon Press

- **Supplementary reading:-**

(A) High Voltage Engineering by J.R. Lucas, 2001
(B) Relevant material from internet
(C) Additional published research papers & handouts will be provided