

Branch Name:	Electrical Engineering
Program Code:	ET109
Course Name:	High Voltage Engineering
Course Code:	1ET1090603
Pre-requisite Course:	Fundamental Knowledge of Field Theory and Electrical Power Generation is required.

Course Objectives:

1. The students will acquire the knowledge regarding the fundamentals of high voltage engineering.
2. To explore the knowledge of different technologies used for the high voltage generation and measurement.
3. Students can also get depth knowledge of different high voltage testing technologies which are used in testing laboratories to assure the quality of insulation of Power Transformers, Circuit Breakers.

Teaching and Examination Scheme:

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)								
Lecture	Tutorial	Practical	Credit	Theory				Practical				Total
				University Assessment		Continuous Assessment		University Assessment		Continuous Assessment		
				Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
3	-	2	4	28	70	12	30	12	30	08	20	150

Course Contents:

Sr. No.	Topic	Total Hours	Weightage (%)
1	Electrostatic fields and field stress control: Electrical field distribution and breakdown strength of insulating materials - fields in homogeneous, isotropic materials - fields in multi-dielectric, isotropic materials - numerical method: Finite Difference Method (FDM).	3	6
2	Electrical breakdown in gases: Gases as insulating media - ionization and decay processes, Townsend first ionization coefficient, photo ionization, ionization by interaction of metastable with atoms, thermal ionization, deionization by recombination, deionization by attachment-negative ion formation, examples - cathode processes – secondary effects, photoelectric emission, electron emission by positive ion and excited atom impact, thermionic emission, field emission, Townsend second ionization coefficient, secondary electron emission by photon impact, examples - transition from non-self-sustained discharges to breakdown, the Townsend mechanism, examples - the streamer or 'kanal' mechanism of spark, examples - the sparking voltage-Paschen's law, penning effect, the breakdown field strength, breakdown in non-uniform fields- partial breakdown, corona discharges.	6	14
3	Breakdown in liquid dielectrics: Liquid as insulators, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, cavity breakdown, examples - static electrification in power transformers, transformer oil filtration,	4	8

	transformer oil test, alternative liquid insulations like vegetable oils, esters and silicon oils.		
4	Breakdown in solid dielectrics: Breakdown in solids, intrinsic breakdown, streamer breakdown, electromechanical breakdown, edge breakdown and treeing, thermal breakdown, erosion breakdown, tracking, breakdown of solid dielectrics in practice, partial discharges in solid insulation, solid dielectrics used in practice.	3	8
5	Generation of High Voltages : Generation of high direct voltages, half and full wave rectifier circuits, voltage multiplier circuits, Van de Graff generators, electrostatic generators, generation of alternating voltages; testing transformers, cascaded transformers, resonant transformers, Standard lightning and switching surge and associated parameters and their corrections, Impulse voltage generator circuits; Marx circuit and Modified Marx circuit , operation, design and construction of impulse generators.	9	20
6	Measurement of High Voltages : High direct voltage measurement, peak voltage measurements by spark gaps, reference measuring systems, uniform field gaps, rod gaps, factors affecting sphere gap measurements, electrostatic voltmeters, high ohmic resistor voltage dividers, generating voltmeters and field sensors, Measurement of High Voltage AC and Impulse: series impedance voltmeter, capacitance voltage transformer, sphere gap for peak measurement, peak reading ac voltmeters, potential divider (resistive& capacitive), impulse voltage measurements; potential divider.	9	20
7	Non-destructive insulation test techniques : Measurement of d.c. resistivity - dielectric loss and capacitance measurements, the Schering bridge, Tan-Delta measurement, null detectors - partial-discharge (PD) measurements, the basic PD test circuit, PD currents, PD measuring systems within the PD test circuit, measuring systems for apparent charge, sources and reduction of disturbances.	4	14
8	Insulation Coordination : Insulation coordination, insulation level, statistical approach to insulation coordination, correlation between insulation and protection levels - modern power systems protection devices, MOA – metal oxide arresters.	4	10

Reference Books:

1. Naidu M. S. and Kamaraju V., "High Voltage Engineering", fourth Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2009.
2. Wadhwa C.L., "High Voltage Engineering", third edition, New Age publishers, New Delhi, 2010.
3. Subir Ray, " An Introduction to High Voltage Engineering " PHI, 2005.
4. Rakosh Das Begamudre, "High Voltage Engineering, Problems and Solutions", New Age International Publishers, New Delhi, 2010.

List of Experiments:

1. To perform breakdown in gaseous dielectric by horn gap apparatus.
2. Testing of transformer oil according to IS:6792.
3. Testing of solid insulation with tape electrodes.

4. Generation of High Voltage D.C. and measurement through sphere gaps assembly.
5. Generation of High voltage A.C. and measurement through sphere gaps assembly.
6. Measurement of HVAC through Rod gaps assembly.
7. Impulse voltage generation through Marx generator.
8. Trace the Electric field through electrolytic tank.
9. Generation and visualization of corona in corona cage.
10. Measurement of High A.C. voltages through capacitor voltage divider.

List of Open Source Software/learning website:

1. <http://www.electrical-engineering-portal.com/>
2. <http://nptel.iitm.ac.in/courses.php>

Course Learning Outcomes (CLO): On completion of this course, the students will be able to:

CLO	Description	Bloom's Taxonomy Level
CLO1	Understand the basic generation and measurement of High voltage and High current for testing purposes	2 Understanding
CLO2	Comprehend Breakdown phenomenon in air, solid and liquid insulation.	4 Analyze
CLO3	Examine the high voltage electrical Equipment with various testing devices.	4 Analyze
CLO4	Express the generation and visualization of corona in corona cage.	2 Understanding
CLO5	Applying High A.C. voltages through capacitor voltage divider.	3 Applying
CLO6	List the non-destructive insulation test techniques.	1 Remembering

Mapping of CLOs with POs & PSOs

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcomes(PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO1		M		L				L	M	L		M			L	
CLO2	L		L			M	L				M		M			
CLO3		M	L		L					M						L
CLO4	H			L			L		H		M	L		L	L	
CLO5				L		H		L								
CLO6		L			L				L			M		L		L

H: High, M: Medium, L: Low