



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

## ELECTRICAL AND ELECTRONICS ENGINEERING

### COURSE DESCRIPTOR

Course Title	<b>HIGH VOLTAGE ENGINEERING</b>				
Course Code	<b>AEE015</b>				
Programme	<b>B.Tech</b>				
Semester	<b>VII</b>	<b>EEE</b>			
Course Type	<b>Core</b>				
Regulation	<b>IARE - R16</b>				
Course Structure	<b>Theory</b>			<b>Practical</b>	
	<b>Lectures</b>	<b>Tutorials</b>	<b>Credits</b>	<b>Laboratory</b>	<b>Credits</b>
	3	1	4	3	2
Chief Coordinator	Mr. G. Kranthi Kumar, Assistant Professor				
Course Faculty	Mr. G. Kranthi Kumar, Assistant Professor				

#### I. COURSE OVERVIEW:

High voltage engineering deals with different mediums of insulation, break down of insulation, understanding need of insulation technology in power system, generation of high direct current and alternating current voltage, measurement of high alternating current and direct current voltages, testing of insulation under all types of conditions using generated high direct current and alternating current voltages

#### II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS006	I	Engineering Physics	4
UG	AEE006	III	Electro Magnetic Field Theory	4

#### III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Power System Analysis	70 Marks	30 Marks	100

#### IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Chalk & Talk	✓	Quiz	✓	Assignments	✗	MOOCs
✓	LCD / PPT	✓	Seminars	✗	Mini Project	✗	Videos
✗	Open Ended Experiments						

#### V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

**Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with “either” or “choice” will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

#### Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz	
CIA Marks	25	05	30

#### Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8<sup>th</sup> and 16<sup>th</sup> week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

#### Quiz :

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

## VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	<b>Engineering knowledge:</b> Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Assignment And Seminar
PO 3	<b>Design/development of solutions:</b> Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Seminar
PO 4	<b>Conduct investigations of complex problems:</b> Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab practice

3 =High;2=Medium;1=Low

## VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	<b>Problem Solving:</b> Exploit the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	2	Assignment And Seminar
PSO2	<b>Professional Skills:</b> Identify the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	-	-
PSO3	<b>Modern Tools in Electrical Engineering:</b> Comprehend the technologies like PLC, PMC, process controllers, transducers and HMI and design, install, test, maintain power systems and industrial applications.	-	-

3 = High; 2 = Medium; 1 = Low

## VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Summarize the types of insulation and breakdown process used for power system protection.
II	Design the networks for generation of high direct current voltage , high alternating current voltage and to measure the same.
III	Identify the causes for over voltages and explain the principals of insulation co-ordination in high voltage power systems.
IV	Measure the various electrical parameters of insulation used for power system equipment for their with stand.
V	Examine breakdown strength of insulation mediums for power system using type and routine test.

## IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO1	Describe the causes of over voltages and its effect and protection against over voltages by using protecting devices.	CLO 1	Study the effect of over voltage on power system and causes.
		CLO 2	Check the causes which lead to over surges and over currents in power system.
		CLO 3	Identify the methods for protection against over voltages in power system.
CO2	Explain the different types breakdown process used in power system protection.	CLO 4	Discuss different phenomenon which leads to break down of gas insulation medium and specify the particular gas any power system apparatus.
		CLO 5	Explain the various methods which causes breakdown in liquid dielectric medium and their importance in power system protection.
		CLO 6	Illustrate the process which decreases the breakdown Strength of solid insulating mediums and their application in power system.
CO 3	Construct the Generation of high voltages and currents and controlling of impulse generators.	CLO 7	Explain the various methods which causes breakdown in liquid dielectric medium and their importance in power system protection.
		CLO 8	Illustrate the process which decreases the breakdown strength of solid insulating mediums and their application in power system.
		CLO 9	Design the networks for generation of high direct current voltages and high alternating current voltages.
		CLO 10	Measure the value of high direct current voltages , high alternating current voltages , impulse voltage and current after generation..
		CLO 11	Analyze tripping and control of impulse generator.
CO 4	Measure the high voltages and currents in power system by using different types of instruments and digital techniques.	CLO 12	Determine the process which leads to over voltage and lightning phenomenon on power system equipment.
		CLO 13	Calculate the DC resistivity, loss factor and dielectric constant of different insulation mediums used in power system protection.
		CLO 14	Examine the power system equipment like insulators, bushings, isolators and circuit breakers for their breakdown strength.
CO 5	Analysing the high voltage apparatus in power system using BIL and international standards and insulation level.	CLO 15	Study the insulation co-ordination in safe operation of extra high voltage power system.
		CLO 16	Identify the difference between type test and routine test used to understand withstand capability of insulation system in power system
		CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.

## X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEE015.01	CLO 1	Study the effect of over voltage on power system and causes	PO1	3
AEE015.02	CLO 2	Check the causes which lead to over surges and over currents in power system.	PO1	2
AEE015.03	CLO 3	Identify the methods for protection against over voltages in power system.	PO1, PO3	3
AEE015.04	CLO 4	Discuss different phenomenon which leads to break down of gas insulation medium and specify the particular gas any power system apparatus.	PO1, PO4	3
AEE015.05	CLO 5	Explain the various methods which causes breakdown in liquid dielectric medium and their importance in power System protection.	PO1, PO4	3
AEE015.06	CLO 6	Illustrate the process which decreases the breakdown Strength of solid insulating mediums and their application in power system.	PO1, PO4	3
AEE015.07	CLO 7	Design the networks for generation of high direct current Voltages and high alternating current voltages.	PO1, PO3	3
AEE015.08	CLO 8	Measure the value of high direct current voltages , high alternating current voltages , impulse voltage and current after generation..	PO1	3
AEE015.09	CLO 9	Analyze tripping and control of impulse generator.	PO1	2
AEE015.10	CLO 10	Determine the process which leads to over voltage and lightning phenomenon on power system equipment.	PO1	2
AEE015.11	CLO 11	Study the insulation co-ordination in safe operation of extra high voltage power system.	PO1	2
AEE015.12	CLO 12	Calculate the DC resistivity , loss factor and dielectric constant of different insulation mediums used in power system protection.	PO1, PO3	3
AEE015.13	CLO 13	Identify the difference between type test and routine test used to understand withstand capability of insulation system in power system.	PO4	2
AEE015.14	CLO 14	Examine the power system equipment like insulators, bushings, isolators and circuit breakers for their breakdown strength.	PO1, PO4	2
AEE015.15	CLO 15	Investigate the power system equipment like cable, transformers and surge arresters of their dielectric strength.	PO1, PO4	2
AEE015.16	CLO 16	Understand importance of high voltage engineering, Insulation technology, generation, measurement and testing related to high voltage power system.	PO1, PO3, PO4	3
AEE015.17	CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive Examinations	PO1, PO3, PO4	3

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**XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES**

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 3	PO 4	PSO1
CO 1	3	2		2
CO 2	2		3	3
CO 3	3	3		3
CO 4	2	3	3	3
CO 5	2	2	3	3

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**XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:**

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												2		
CLO 2	2												2		
CLO 3	3		2										2		
CLO 4	2			3									3		
CLO 5	2			3									3		
CLO 6	2			3									3		
CLO 7	2		3										2		
CLO 8	3												2		
CLO 9	2												2		
CLO 10	2												3		
CLO 11	2												2		
CLO 12	2		3										2		
CLO 13				2									3		
CLO 14	1			3									3		
CLO 15	1			3									3		
CLO 16	2		3	3									3		
CLO 17	2		3	3		2	2					3	2		

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### XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1,PO3 PO4,PSO1	SEE Exams	PO1,PO3 PO4,PSO1	Assignments	PO1,PO3 PO4	Seminars	PO1,PO3 PO4
Laboratory Practices	PO1,PO3 PO4	Student Viva	PO1,PO3 PO4	Mini Project	-	Certification	-
Term Paper	-						

### XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

### XV. SYLLABUS

<b>UNIT-I</b>	<b>OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS</b>
Origin of over voltages: Causes of over voltages and their effects on power system, lightning, switching surges and temporary over voltages, corona and its effects, reflection and refraction of travelling waves, Protection against over voltages.	
<b>UNIT-II</b>	<b>DIELECTRIC BREAKDOWN</b>
Breakdown of dielectrics: Gaseous breakdown in uniform and non uniform fields, corona discharges, breakdown of vacuum, conduction and breakdown in pure and commercial liquids, maintenance of oil quality, breakdown mechanisms in solid and composite dielectrics.	
<b>UNIT-III</b>	<b>GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS</b>
High AC, DC voltages and currents: Generation of high DC, AC and impulse voltages and currents.  Triggering: Triggering and control of impulse generators.	
<b>UNIT-IV</b>	<b>MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS</b>
High voltage and current measurement: High resistance with series ammeter, dividers, resistance, capacitance and mixed dividers, peak voltmeter, generating voltmeters, capacitance voltage transformers, electrostatic voltmeters, sphere gaps, high current shunts, digital techniques in high voltage measurement.	
<b>UNIT-V</b>	<b>HIGH VOLTAGE TESTING AND INSULATION COORDINATION</b>
Testing: High voltage testing of electrical power apparatus as per international and Indian standards, power frequency, impulse voltage and dc testing of insulators, circuit breakers, bushings, isolators and transformers, insulation coordination.	
<b>Text Books:</b>	
<ol style="list-style-type: none"> <li>1. S Naidu, V Kamaraju, “High Voltage Engineering”, Tata McGraw-Hill, 5<sup>th</sup> Edition, 2013.</li> <li>2. E Kuffel, W S Zaengl, J Kuffel, “High voltage Engineering fundamentals”, Newnes, 2<sup>nd</sup> Edition Elsevier, New Delhi, 2005.</li> <li>3. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning Private Limited, New Delhi, 2<sup>nd</sup> Edition, 2013.</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. L L Alston, “High Voltage Technology”, Oxford University Press, 1<sup>st</sup> Indian Edition, 2011.</li> <li>2. C L Wadhwa, “High Voltage Engineering”, New Age International Publishers, 3<sup>rd</sup> Edition, 2010.</li> </ol>	

## XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No.	Topics to be covered	CLOs	Reference
1	Study the causes of over voltages and their effect.	CLO2	T1:8.1 R2:7.5
2	Study the causes of over voltages and their effect.	CLO2	T1:8.1 R2:7.5
3	Understand switching surges , temporary over voltages, corona and its effects .	CLO1	T1:8.2 R2:7.8
4	Understand switching surges , temporary over voltages, corona and its effects .	CLO1	T1:8.2 R2:7.8
5	Explain reflection and refraction of travelling waves.	CLO2	T1:8.2 R2:7.3
6	List of methods to protect against over voltage.	CLO3	T1:1.6 R2:7.10
7	Discuss gases as insulating media, collision process, Ionization Process.	CLO4	T1:2.1 R2:1.0-1.1
8	Explain Primary and secondary ionization process.	CLO4	T1:2.2 R2:1.1
9	Study Townsend's criteria of breakdown in gases,	CLO4	T1:2.3-2.4 R2:1.2
10	Plot Paschen's law. Introduce Liquid as Insulator.	CLO4	T1:2.10 R2:1.7
11	Distinguish between pure and commercial liquids, breakdown in pure and commercial liquids.	CLO5	T1:3.1-3.2 R2:1.11
12	Understand Purification process of commercial liquids.	CLO5	T1:3.2 R2:1.11
13	Examine Intrinsic breakdown, elector mechanical breakdown.	CLO6	T1:4.1-4.2 R2:1.14
14	Check thermal breakdown, breakdown of solid dielectrics in practice.	CLO6	T1:4.4 R2:1.14
15	Process of Treeing and tracking in solid insulation	CLO6	T1:4.5 R2:1.14
16	Breakdown in composite dielectrics, solid dielectrics used in practice.	CLO6	T1:4.7 R2:1.14
17	Design circuits for Generation of High Direct Current Voltages.	CLO7	T1:6.1 R2:2.1-2.3
18	Design circuits for Generation of High Direct Current Voltages.	CLO7	T1:6.1 R2:2.1-2.3
19	Construct circuits for Generation of High alternating voltages.	CLO7	T1:6.2 R2:2.4
20	Construct circuits for Generation of High alternating voltages.	CLO7	T1:6.2 R2:2.4
21	Discuss Methods to Generation of Impulse Voltages.	CLO7	T1:6.3 R2:3.2
22	Discuss Methods to Generation of Impulse Voltages.	CLO7	T1:6.3 R2:3.2
23	Know Tripping and control of impulse generators.	CLO9	T1:6.5 R2:3.7
24	Know Tripping and control of impulse generators.	CLO9	T1:6.5 R2:3.7
25	Measurement of High Direct Current voltages, High Voltages alternating and impulse, High Voltages alternating and impulse and High Currents direct.	CLO8	T1:7.1-7.2 R2:4.1-4.6



Lecture No.	Topics to be covered	CLOs	Reference
26	Measurement of High Direct Current voltages, High Voltages alternating and impulse, High Voltages alternating and impulse and High Currents direct.	CLO8	T1:7.1-7.2 R2:4.1-4.6
27	Measurement of high alternating and Impulse currents, high alternating and Impulse currents, impulse voltage and current measurements	CLO8	T1:7.2-7.3 R2:4.1-4.6
28	Measurement of high alternating and Impulse currents, high alternating and Impulse currents, impulse voltage and current measurements	CLO8	T1:7.2-7.3 R2:4.1-4.6
29	Measurement of high alternating and Impulse currents, high alternating and Impulse currents, impulse voltage and current measurements	CLO8	T1:7.2-7.3 R2:4.1-4.6
30	Observe Oscilloscope for measurement of peak voltages, impulse voltage and current measurements.	CLO8	T1:7.4 R2:6.11
31	Observe Oscilloscope for measurement of peak voltages, impulse voltage and current measurements.	CLO8	T1:7.4 R2:6.11
32	Understand Natural causes for over voltages.	CLO10	T1:8.1 R2:7.2
33	Explain the concept of Lightning phenomenon.	CLO10	T1:8.2 R2:7.6
34	Discuss over Voltage due to switching surges.	CLO10	T1:8.2 R2:7.8
35	Discuss over Voltage due to switching surges.	CLO10	T1:8.2 R2:7.8
36	Discuss over Voltage due to switching surges.	CLO10	T1:8.2 R2:7.8
37	Understand systems faults and other abnormal conditions.	CLO10	T1:8.3 R2:7.2
38	Understand systems faults and other abnormal conditions.	CLO10	T1:8.3 R2:7.2
39	Explain Principals of insulation Coordination voltage and Extra High Voltage power systems.	CLO11	T1:7.9 R2:7.2
40	Explain Principals of insulation Coordination voltage and Extra High Voltage power systems.	CLO11	T1:7.9 R2:7.2
41	Measurement of D.C Resistivity.	CLO12	T1:9.2 R2:7.2
42	Measurement of D.C Resistivity.	CLO12	T1:9.2 R2:7.2
43	Measurement of Dielectric Constant and loss factor.	CLO12	T1:9.3 R2:7.2
44	Measurement of Dielectric Constant and loss factor.	CLO12	T1:9.3 R2:7.2
45	Calculate Partial discharge measurements.	CLO12	T1:9.4 R2:7.2
46	Calculate Partial discharge measurements	CLO12	T1:9.4 R2:7.2
47	Introduction to testing of insulator.	CLO14	T1:10.1 R2:5.1
48	Study Testing procedures of bushings.	CLO14	T1:10.1 R2:5.3
49	Examine withstand capacity of Isolators.	CLO14	T1:10.2 R2:5.1
50	Observe breakdown phenomenon of circuit breakers.	CLO14	T1:10.2 R2:5.6
51	Observe breakdown phenomenon of circuit breakers.	CLO14	T1:10.2 R2:5.6

Lecture No.	Topics to be covered	CLOs	Reference
52	Check with stand voltage of cables.	CLO15	T1:10.3 R2:5.2
53	Testing of Transformers and Surge Arresters.	CLO15	T1:10.5 R2:5.7
54	Testing of Transformers and Surge Arresters.	CLO15	T1:10.5 R2:5.7
55	Understand importance of insulation co-ordination.	CLO11	T1:8.3 R2:7.9

**XVII.GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:**

S. No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	More content of Tesla coil may be suggested.	Seminars / NPTEL	PO1, PO3	PSO1
2	Testing of breakdown Strength of insulation practically.	Lab Practice	PO1, PO3,PO4	PSO1

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