INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**EHVAC TRANSMISSION**			
Course Code	**AEE504**			
Programme	**B.Tech**			
Semester	**VIII**			
Course type	**Core**			
Regulation	**R16**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	**-**	**-**	**4**
Chief Coordinator	**Ms.P.Sravani, Assistant Professor**			
Course Coordinator	**Ms. P.Sravani, Assistant Professor**			

I. COURSE OVERVIEW:

Modern power transmission is utilizing voltages between 345 kV and 1150 kV, A.C. Distances of transmission and bulk powers handled have increased to such an extent that extra high voltages and ultra high voltages (EHV and UHV) are necessary. The problems encountered with such high voltage transmission lines exposed to nature are electrostatic fields near the lines, audible noise, radio interference, corona losses, carrier and TV interference, high voltage gradients, heavy bundled conductors, control of voltages at power frequency using shunt reactors of the switched type which inject harmonics into the system, switched capacitors, overvoltage's caused by lightning and switching operations, long air gaps with weak insulating properties for switching surges, ground-return effects, and many more. This course covers all topics that are considered essential for understanding the operation and design of EHV ac overhead lines and underground cables. Theoretical analyses of all problems combined with practical application are dealt in this course.

II. PREREQUISITES:

Level	Course code	Semester	Prerequisite
UG	AEE015	VII	High Voltage Engineering
UG	AEE011	V	Transmission and distribution systems

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
EHVAC Transmission	70 Marks	30 Marks	100

IV. INSTRUCTIONAL METHODOLOGY:

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

V. EVALUTION 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 modules and each module 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 module. 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 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

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

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of five descriptive type questions out of which four 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 / Alternative Assessment Tool (AAT):

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		Strength	Proficiency Assessed By
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Exercises
PO3	**Design / Development of solutions**: 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.	2	-----
PO4	**Conduct Investigations of Complex Problems:** 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.	2	-------
PO5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	-------
PO6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3	Seminars, Prototypes
PO7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Seminars, Discussions

PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	-----
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	-----
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	-----
PO11	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	Workshops, Prototypes
PO12	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Seminar, Discussions

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency Assessed By
PSO1	**Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	2	Lectures, Assignments
PSO2	**Problem-Solving Skills:** Can explore 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.	1	------
PSO3	**Successful Career and Entrepreneurship:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications.	2	Guest Lectures

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVE:

This course enables the students to:

I Illustrate basic concepts of extra high voltage AC transmission and understand the need for it.
II Outline the line and ground reactive parameters and voltage gradients of conductors.
III Describe effects of corona and methods of associated measurement.
IV Associate the knowledge of electro static field theory and traveling wave theory.
V Select voltage control methods for extra high voltage AC transmission system.

IX. COURSE OUTCOMES:

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Student can learn about the trends in EHV AC transmission.	CLO 1	Student shall learn the necessity of EHVAC Transmission.
		CLO 2	Student will come to know the advantages and problems in EHVAC Transmission.
		CLO 3	Student learns the power handling capability and line losses in EHVAC Transmission.
		CLO 4	Student understands the concept of bundle conductors
CO 2	Student can calculate the line inductance and capacitance of bundle conductors	CLO 5	Student can calculate line inductance.
		CLO 6	Student can calculate line capacitance .
		CLO 7	Student learns the concept of sequence inductance and sequence capacitance.
		CLO 8	Student learns different modes of propagation and ground return.
		CLO 9	Student can calculate gradient of bundle conductors.
		CLO 10	Student can solve various design examples.
CO 3	Student understands the effect of Corona and radio interference.	CLO 11	Student learns about the concept of power loss and audible noise due to Corona.
		CLO 12	Student can derive the formula for corona loss .
		CLO 13	Calculate the audible niose and can measure its limits .
		CLO 14	Student can understand the relationship between single phase and three phase audible noise levels.
		CLO 15	Student learns the concept of radio interference.
CO 4	Explore the concept of Electro static field and the travelling wave theory.	CLO 16	Student can calculate electrostatic field of EHV transmission lines.
		CLO 17	Understand the effect of electrostatic field on humans ,animals and plants.
		CLO 18	Student can estimate the electrostatic induction in un-energized circuit of double ,circuit line.
		CLO 19	Student can derive travelling wave expression and its solution
		CLO 20	Student learns about source of excitation and terminal conditions.
CO 5	Student can analyze compensated devices for voltage control.	CLO 21	Student learns about power circle diagram and its uses.
		CLO 22	Student understands the concept of synchronous condenser.
		CLO 23	Student learns the concept of static VAR compensation.

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
AEE504.01	CLO 1	Student shall learn the necessity of EHVAC Transmission.	PO 1	3
AEE504.02	CLO 2	Student will come to know the advantages and problems in EHVAC Transmission.	PO 2	2
AEE504.03	CLO 3	Student learns the power handling capability and line losses in EHVAC Transmission.	PO 1	3
AEE504.04	CLO 4	Student understands the concept of bundle conductors.	PO 1	3
AEE504.05	CLO 5	Student can calculate line inductance.	PO 2	2
AEE504.06	CLO 6	Student can calculate line capacitance	PO 2	2
AEE504.07	CLO 7	Student learns the concept of sequence inductance and sequence capacitance.	PO 2	2
AEE504.08	CLO 8	Student learns the concept of sequence inductance and sequence capacitance.	PO 2	2
AEE504.09	CLO 9	Student learns different modes of propagation and ground return.	PO 3	1
AEE504.10	CLO 10	Student can calculate gradient of bundle conductors.	PO 3	1
AEE504.11	CLO 11	Student can solve various design examples.	PO 3	2
AEE504.12	CLO 12	Student learns about the concept of power loss and audible noise due to Corona.	PO 2	2
AEE504.13	CLO 13	Student can derive the formula for corona loss .	PO 1	3
AEE504.14	CLO 14	Student can understand the relationship between single phase and three phase audible noise levels.	PO 1	3
AEE504.15	CLO 15	Student learns the concept of radio interference.	PO 1	3
AEE504.16	CLO 16	Student can calculate electrostatic field of EHV transmission lines.	PO 1, PO 2	3
AEE504.17	CLO 17	Understand the effect of electrostatic field on humans ,animals and plants.	PO 1, PO 2	3
AEE504.18	CLO 18	Student can estimate the electrostatic induction in un-energized circuit of double ,circuit line.	PO 1, PO 2	3
AEE504.19	CLO 19	Student can derive travelling wave expression and its solution	PO 1, PO 2	3
AEE504.20	CLO 20	Student learns about source of excitation and terminal conditions.	PO 1, PO 2	3
AEE504.21	CLO 21	Student learns about power circle diagram and its uses.	PO 1	3
AEE504.22	CLO 22	Student understands the concept of synchronous condenser.	PO 1	3
AEE504.23	CLO 23	Student learns the concept of static VAR compensation.	PO 1	3

3= High; 2 = Medium; 1 = Low

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

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

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

Course Learning 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												1		
CLO 2		2													
CLO 3	3												1		
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7		2													
CLO 8		2													
CLO 9				1											
CLO 10				1											
CLO 11			2										1		
CLO 12		2											1		
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3	2											1		
CLO 17	3	2											1		
CLO 18	3	2											1		
CLO 19	3	2											1		
CLO 20	3	2											1		
CLO 21	3														

Course Learning 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 22	3														
CLO 23	3														

3 = High; 2 = Medium; 1 = Low

XIII ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4,PSO1	SEE Exams	PO1, PO2, PO4,PSO1	Assignments	PSO 1	Seminars	PO1, PO2, PO4,PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV.ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV.SYLLABUS

UNIT-I	PRELIMINARIES
Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses- mechanical considerations – resistance of conductors – properties of bundled conductors – bundle spacing and bundle radius- Examples.	
UNIT-II	**LINE AND GROUND REACTIVE PARAMETERS AND VOLTAGE GRADIENTS OF CONDUCTORS**
Reactive parameters: Line inductance and capacitances, sequence inductances and capacitances, modes of propagation, ground return, examples, electrostatics, field of sphere gap, field of line changes and properties, charge, potential relations for multi conductors; Voltage gradient: Surface voltage gradient on conductors, distribution of voltage gradient on sub conductors of bundle, examples.	
UNIT-III	**CORONA EFFECTS**
Power loss and audible noise (AN) – corona loss formulae – charge voltage diagram – generation, characteristics – limits and measurements of AN – relation between 1-phase and 3-phase AN levels – Examples. Radio interference (RI) – corona pulses generation, properties, limits – frequency spectrum – modes of propagation – excitation function – measurement of RI, RIV and excitation functions – Examples.	
UNIT-IV	**ELECTRO STATIC FIELD AND TRAVELING WAVE THEORY**
Electro Static Field: calculation of electrostatic field of EHV/AC lines – effect on humans, animals and plants – electrostatic induction in unenergized circuit of double-circuit line – electromagnetic interference-Examples. **Traveling wave theory:** Traveling wave expression and solution- source of excitation- terminal conditions- open circuited and short-circuited end- reflection and refraction coefficients-Lumped parameters of distributed lines-generalized constants-No load voltage conditions.	

UNIT-V	VOLTAGE CONTROL
Power circle diagram and its use – voltage control using synchronous condensers – cascade connection of shunt and series compensation – sub synchronous resonance in series capacitor – compensated lines – static VAR compensating system.	
Text Books:	
1 EHVAC Transmission Engineering by R. D. Begamudre, New Age International (p) Ltd. 2 HVAC and DC Transmission by S. Rao 3 Padiyar K.R., "HVDC Power Transmission Systems" -New age International Ltd.	
Reference Books:	
1. Arrilaga, J, "High voltage direct current transmission", peter pereginver Ltd., London, U.K.1983 2. Kimbark, E.W, "Direct current transmission-vol.1", Wiley Interscience, New York, 1970	

XVI.COURSE PLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Necessity of EHVAC Transmission.	CLO 1	T1: 1.1
2-3	Advantages and problems in EHVAC Transmission.	CLO 2	T1: 1.2
4-5	Power handling capability and line losses in EHVAC Transmission.	CLO 3	T1: 2.3
6-7	Properties of bundle conductors	CLO 4	T1:3.3
8-9	Calculation of line inductance.	CLO 5	T1:3.4
10-11	Calculation of line capacitance .	CLO 6	T1:3.5
12-13	Sequence inductance and sequence capacitance.	CLO 7	T1:3.6
14-15	Modes of propagation and ground return.	CLO 8	T1:3.8
16-18	Gradient of bundle conductors.	CLO 9	T1:3.3-3.5
19-20	Design examples.	CLO 10	T1:3.6
21-22	Power loss and audible noise due to Corona.	CLO 11	T1:5.1
23	Formula for corona loss .	CLO 12	T1:5.2
24-25	Calculation of the audible noise and the measure its limits .	CLO 13	T1:5.7

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
26-27	Student can understand the relationship between single phase and three phase audible noise levels.	CLO 14	T1:5.11
28	Radio interference.	CLO 15	T1:6.7
29	Electrostatic field of EHV transmission lines.	CLO 16	T1:7.3
30	Effect of electrostatic field on humans ,animals and plants.	CLO 17	T1:7.4
31-33	Estimate the electrostatic induction in un-energized circuit of double ,circuit line.	CLO 18	T1:7.6
34	Derivation of travelling wave expression and its solution	CLO 19	T1:8.1
35	Reflection and refraction of travelling waves.	CLO 20	T1:8.9
36	Transient response of system with series and shunt lumped parameters and distributed lines.	CLO 20	T1:8.10
37	Power circle diagram and its uses.	CLO 21	T1:12.4
38	Concept of voltage control through synchronous condenser	CLO 22	T1:12.5
39	Series capacitor compensation	CLO 22	T1:12.6
40-41	Cascade connection of shunt and series compensation	CLO 22	T1:12.6
42	Sub synchronous reactance in series capacitor	CLO 23	T1:12.7
43	Sub synchronous reactance in compensated lines	CLO 23	T1:12.7
44-45	Static VAR compensation	CLO 23	T1:12.8

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

S .No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Evolution of latest trends	Seminars	PO 5	PSO 1
2	Industrial needs must be accomplished.	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 6	PSO 1

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