INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**EHVAC TRANSMISSION**			
Course Code	**A80235**			
Regulation	**R13**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	**-**	**-**	**4**
Course Coordinator	**Dr. P Sridhar, Professor**			
Team of Instructors	**Ms. B Navothna, 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	Credits	Periods	Prerequisite
UG	4	4	High Voltage Engineering

III. COURSE ASSESSMENT METHODS:

a) Marks distribution:

Session Marks	University End Exam Marks	Total Marks
There shall be two mid tem examinations. Each id term exam consists of subjective type and objective type test. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each semester shall contain four questions; the student has to	75	100

answer two out of them. Each carrying 5 marks The objective test paper Is prepared by JNTUH, which consists of 20 questions each carrying 0.5 marks and total of 10 marks. The student is assessed by giving two assignments, one, after completion of first 2 and half units and the second remaining portion, each carrying 5 marks. On the total the internal marks are 25. The average of two internal tests is the final internal marks. The external question paper is set by JNTUH consisting of part –A and part-B. Where part A consists of short answer questions carrying total marks of 25 and part-B consists of 10 essay type questions consists of internal choice each carrying 10 marks and the total of 50. The total external marks are 75.		

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1	I Mid Examination	80 minutes	20
2	I Assignment	--	05
3	II Mid Examination	80 minutes	20
4	II Assignment	--	05
5	External Examination	3 hours	75

V. COURSE OBJECTIVE:

This course enables the students to:

i. Provide In-depth understanding of different aspects of Extra High Voltage AC transmission system design and Analysis.
ii. Understand the concept of Voltage gradients of conductors.
iii. Develop the empirical formula to determine the Corona loss occurring in EHV AC transmission Line.
iv. Determine the interference caused by Corona and to measure its magnitude.
v. Derive the expression and possible solution for travelling wave and its source of excitation.

VI. COURSE OUTCOMES:

After completing this course the student can:

1. Discuss about the trends in EHV AC Transmission.
2. Analyze Line inductance and capacitances of bundled conductors.
3. Analyze calculate voltage gradient of bundled conductors.
4. Describe the effects of corona like Audible noise.
5. Describe the effect of Radio Interference.
6. Analyze electrostatic field of EHV AC lines.
7. Discuss the effect of high electrostatic field on humans, plants and animals.
8. Explain about travelling waves.

9. Explain about compensated devices for voltage control.
10. Estimate power circle diagram and its use.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	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.	H	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.	H	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.	N	-----
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.	N	-------
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.	N	-------
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.	H	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.	H	Seminars, Discussions
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	N	-----
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	N	-----

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.	N	-----
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.	H	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.	S	Seminar, Discussions

N= None **S=Supportive** **H=highly related**

VIII. 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.	S	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.	N	------
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.	S	Guest Lectures

N - None **S - Supportive** **H - Highly Related**

IX. SYLLABUS:

UNIT-I:

Introduction: 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.

Line and ground reactive parameters: Line inductance and capacitances – sequence inductances and capacitances – modes of propagation – ground return – Examples.

UNIT-II:

Voltage Gradients of Conductors: Electrostatics – field of sphere gap – field of line changes and

properties – charge – potential relations for multi-conductors – 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:** calculation of electrostatic field of EHV/AC lines – effect on humans, animals and plants – electrostatic induction in unenergised 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 and charging current.
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.

X. COURSE PLAN:

At the end of the course, the students are able to achieve the following course learning outcomes:

Lecture No.	Learning Objectives	Topics to be Covered	Reference
1	To know necessity of EHV AC transmission	Necessity of EHV AC transmission	T1: 1.1
2	To understand advantages and problems of EHV AC transmission	advantages and problems of EHV AC transmission	T1: 1.2
3,4	To understand power handling capacity and line losses	power handling capacity and line losses	T1: 2.3
5	To know mechanical considerations	mechanical considerations	T1: 2.6
6	To understand resistance of conductors	resistance of conductors	T1:3.1
7	To understand properties of bundled conductors	properties of bundled conductors	T1:3.3
8	To understand bundle spacing and bundle radius	bundle spacing and bundle radius	T1:3.3.1
9	To solve examples based on bundle spacing and bundle radius	To solve examples based on bundle spacing and bundle radius	T1:3.3.2
10	To understand Line inductance and capacitances	Line inductance and capacitances	T1:3.4-3.5
11,12	To understand sequence inductances and capacitances	sequence inductances and capacitances	T1:3.6

13	To understand modes of propagation	modes of propagation	T1:3.7
14	To understand ground return and Examples related to inductances and capacitance	ground return and Examples related to inductances and capacitance	T1:3.8
15	To know Electrostatics	Electrostatics	T1:4.1
16,17	To understand field of sphere gap	field of sphere gap	T1:4.2
18	To understand field of line changes and properties	field of line changes and properties	T1:4.3
19	To understand charge – potential relations for multi-conductors	charge – potential relations for multi-conductors	T1:4.4
20	To understand surface voltage gradient on conductors	surface voltage gradient on conductors	T1:4.5
21	To understand distribution of voltage gradient on sub-conductors of bundle	distribution of voltage gradient on sub-conductors of bundle	T1:4.8
22	To solve Examples on voltage gradients on conductors	Example problems	T1:4.8.1
23	To understand Power loss and audible noise (AN)	Power loss and audible noise (AN)	T1:5.1
24	To know corona loss formulae	corona loss formulae	T1:5.2
25	To understand charge voltage diagram, generation, characteristics	charge voltage diagram – generation, characteristics	T1:5.3
26	To know limits and measurements of AN	limits and measurements of AN	T1:5.6-5.7
27,28	To understand 1-phase and 3-phase AN levels with Examples	1-phase and 3-phase AN levels with Examples	T1:5.9
29	To know Radio interference (RI)	Radio interference (RI)	T1:6.1
30	To understand corona pulses generation, properties, limits	corona pulses generation, properties, limits	T1:6.2-6.3
31,32	To understand frequency spectrum, modes of propagation	frequency spectrum, modes of propagation	T1:6.4
33	To understand excitation function	excitation function	T1:6.7
34,35	To understand measurement of RI, RIV and excitation functions and Examples	measurement of RI, RIV and excitation functions and Examples	T1:6.8-6.9
36	To understand calculation of electrostatic field of EHV/AC lines	calculation of electrostatic field of EHV/AC lines	T1:7.3
37,38	To understand effect on humans, animals and plants	effect on humans, animals and plants	T1:7.4
39,40	To know electrostatic induction in unenergised circuit of double-circuit line	electrostatic induction in unenergised circuit of double-circuit line	T1:7.5-7.6

41	To know electromagnetic interference	electromagnetic interference	T1:7.7
42,43	To solve electromagnetic interference Examples	electromagnetic interference Examples	T1:7.7.1
44	To understand traveling wave expression and solution	traveling wave expression and solution	T1:7.8
45	To understand source of excitation, terminal conditions	source of excitation, terminal conditions	T1:8.2.1
46,47	To understand open circuited and short-circuited end, reflection and refraction coefficients	open circuited and short-circuited end, reflection and refraction coefficients	T1:8.9
48,49	To know Lumped parameters of distributed lines-generalized constants	Lumped parameters of distributed lines-generalized constants	T1:10.7
50	To understand No load voltage conditions and charging current	No load voltage conditions and charging current	T1:12.3
51,52	To understand Power circle diagram and its use	Power circle diagram and its use	T1:12.4
53, 54	To understand voltage control using synchronous condensers	voltage control using synchronous condensers	T1:12.5
55,56	To understand shunt capacitors	shunt capacitors	T1:12.6.2
57,58	To understand cascade connection of shunt and series compensation	cascade connection of shunt and series compensation	T1:12.6
59	To understand sub synchronous resonance in series capacitor ,compensated lines	sub synchronous resonance in series capacitor , compensated lines	T1:12.7
60	To understand static VAR compensating system	static VAR compensating system	T1:12.8

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.

REFERENCES:

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, 1971.

XIV. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
I	H	H	-	-	-	H	-	S	-	-	H	S	S	-	-

II	H	H	-	-	-	H	H	S	-	-	H	S	S	-	-
III	H	S	-	-	-	H	S	H	-	-	S	H	-	-	S
IV	S	S	-	-	-	S	-	H	-	-	-	S	S	-	S
V	H	S	-	-	-	S	-	S	-	-	S	S	S	-	S

N - None **S – Supportive** **H - Highly Related**

XV. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOME

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
I	S	H	-	-	-	H	H	S	-	-	H	S	S	-	-
II	S	S	-	-	-	H	S	S	-	-	S	-	-	-	S
III	H	H	-	-	-	H	H	S	-	-	H	S	S	-	-
IV	H	S	-	-	-	H	S	H	-	-	S	H	-	-	S
V	S	S	-	-	-	S	-	H	-	-	-	S	S	-	S
VI	H	S	-	-	-	S	-	S	-	-	S	S	S	-	-
VII	S	S	-	-	-	H	S	S	-	-	S	-	-	-	-
VIII	H	S	-	-	-	H	S	H	-	-	S	H	-	-	S
IX	H	S	-	-	-	S	-	S	-	-	S	S	S	-	S
X	H	S	-	-	-	S	-	S	-	-	S	S	S	-	-

N - None **S – Supportive** **H - Highly Related**

Prepared by:

Ms. B Navothna, Assistant Professor

HOD, EEE