INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	TRANSMISSION AND DISTRIBUTIION SYSTEMS				
Course Code	AEE011				
Programme	B. Tech				
Semester	V	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Ms. T Saritha Kumari, Assistant Professor, EEE				
Course Faculty	Ms. T Saritha Kumari, Assistant Professor, EEE Mr. P Mabuhusssain, Assistant Professor, EEE				

I. COURSE OVERVIEW:

This course deals with the basic theory of Transmission lines modeling and their performance analysis. Also this course gives emphasis on mechanical design of transmission lines, cables and insulators. It also focuses on different distribution systems and calculation of voltage drops in distribution systems. It also gives an attention on the Indian electricity rules to be followed and present energy scenario in India.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEE003	III	Power Generation systems	4
UG	AEE005	III	Network Analysis	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Transmission and Distribution systems	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/AAT.

Table 1: Assessment pattern for CIA

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 - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

	Program Outcomes (POs)	Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Seminars
PO 2	**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	2	Assignments
PO 3	**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	Assignments
PO 4	**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	Assignments

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

	Program Specific Outcomes (PSOs)	Strength	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	Seminars
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.

| 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. | - | - |

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Determine the performance parameters of transmission lines.
II	Evaluate the voltage regulation and efficiency of short, medium and long transmissions lines.
III	Demonstrate the mechanical design of overhead line insulators and cables.
IV	Illustrate the importance of sag in the design of overhead transmission lines.
V	Discuss the operation of different distribution schemes and design of feeders.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Determine the value of Resistance, inductance and capacitance of transmission lines and study the effect of corona.	CLO 1	Formulate the transmission line parameters (resistance, inductance and capacitance)
		CLO 2	Estimate the value of inductance and capacitance of different.
		CLO 3	Illustrate the effect of ground on the capacitance calculations
		CLO 4	Explain the effect corona in overhead transmission lines.
CO 2	Model the short, medium and long transmission lines and study the Ferranti effect and surge impedance loading.	CLO 5	Classify the transmission lines based on the length of the conductor and voltage levels.
		CLO 6	Analyze the nominal T model, nominal-π and end capacitor models of medium transmission and long transmission lines
		CLO 7	Evaluate the efficiency and regulation of short, medium and long length transmission lines.
		CLO 8	Describe Ferranti effect in long transmission lines.
CO 3	Demonstrate the working of different types of insulators, calculate the string efficiency and also illustrate the importance of underground cables.	CLO 9	Differentiate different insulators used in overhead and underground transmission systems.
		CLO 10	Determine the string efficiency of suspension type insulators and discuss the methods to improve string efficiency.

COs	Course Outcome	CLOs	Course Learning Outcome
		CLO 11	Construct single core and three core underground cables for transmission of power in highly populated areas.
CO 4	Estimate the Sag and tension in overhead transmission lines in different conditions.	CLO 12	Calculate the sag and tension with equal and unequal heights of towers
		CLO 13	Illustrate the effect of wind and ice on weight of the conductors for the calculation of sag.
CO 5	Discuss the different types of distribution systems, its economic considerations along with the Indian electricity rules and present grid scenario.	CLO 14	Compare different distribution systems (AC Vs DC distribution, Ring main Vs Radial).
		CLO 15	Evaluate the voltage drops in AC distributors and DC distributors.
		CLO 16	Indian electricity rules, various voltage levels of transmission and distribution systems and present Indian grid scenario.

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
AEE011.01	CLO 1	Formulate the transmission line parameters (resistance, inductance and capacitance)	PO1,PO2, PO3, PSO1	3
AEE011.02	CLO 2	Estimate the value of inductance and capacitance of different.	PO1, PO2, PO3, PO4	2
AEE011.03	CLO 3	Illustrate the effect of ground on the capacitance calculations	PO1, PO2, PO3, PO4	1
AEE011.04	CLO 4	Explain the effect corona in overhead transmission lines.	PO1, PO2, PO3, PO4, PSO1	2
AEE011.05	CLO 5	Classify the transmission lines based on the length of the conductor and voltage levels.	PO3	2
AEE011.06	CLO 6	Analyze the nominal T model, nominal-π and end capacitor models of medium transmission and long transmission lines	PO1, PO2, PO3, PO4	2
AEE011.07	CLO 7	Evaluate the efficiency and regulation of short, medium and long length transmission lines.	PO1, PO2, PO3, PO4	1
AEE011.08	CLO 8	Describe Ferranti effect in long transmission lines.	PO3, PO4, PSO1	2
AEE011.09	CLO 9	Differentiate different insulators used in overhead and underground transmission systems.	PO3, PO4, PSO1	1
AEE011.10	CLO 10	Determine the string efficiency of suspension type insulators and discuss the methods to improve string efficiency.	PO3, PO4, PSO1	2
AEE011.11	CLO 11	Construct single core and three core underground cables for transmission of power in highly populated areas.	PO2, PO3, PO4	2
AEE011.12	CLO 12	Calculate the sag and tension with equal and unequal heights of towers	PO1, PO2, PO4	2
AEE011.13	CLO 13	Illustrate the effect of wind and ice on weight of the conductors for the calculation of sag.	PO1, PO2	2
AEE011.14	CLO 14	Compare different distribution systems (AC Vs DC distribution, Ring main Vs Radial).	PO2, PO4, PSO1	2
AEE011.15	CLO 15	Evaluate the voltage drops in AC distributors and DC distributors.	PO2, PO3, PO4	2
AEE011.16	CLO 16	Discuss parameters to design a substation, Indian electricity rules, various voltage levels of transmission and distribution systems and present Indian grid scenario.	PO2, PSO1	2

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

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

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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	3										2		
CLO 2	3	3	1	1											
CLO 3	1	1	1	1											
CLO 4	1	1	2	2									2		
CLO 5			2												
CLO 6	1	1	2	3											
CLO 7	1	1	1	2											
CLO 8			2	2									2		
CLO 9			1	1									2		
CLO 10			2	2									2		
CLO 11		2	2	2											
CLO 12	2	2		1											
CLO 13	2	2													
CLO 14		2		2									2		
CLO 15		2	2	3											
CLO 16		2											2		

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3, PO4	SEE Exams	PO1, PO2, PO3, PO4	Assignments	PO2, PO3, PO4	Seminars	PO1
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	TRANSMISSION LINE PARAMETERS

Transmission line parameters: Types of conductors, simple diagrams of typical towers and conductors for 400, 220 and 132 kV operations, calculation of resistance for solid conductors, calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR and GMD, symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems, capacitance calculations for symmetrical and asymmetrical single and three phase lines, single and double circuit lines, effect of ground on capacitance, numerical problems; Corona: Types, critical disruptive voltages, factors affecting corona, methods for reducing corona power loss, charge voltage diagram, audible noise, radio interference.

UNIT-II	MODELING AND PERFORMANCE OF TRANSMISSION LINES

Classification of transmission lines: Short, medium and long line and their model representations, nominal T, nominal π and A, B, C, D constants for symmetrical and asymmetrical networks, numerical problems, mathematical solutions to estimate regulation and efficiency of all types of lines, numerical problems; Long transmission line: Rigorous solution, evaluation of A, B, C, D constants, interpretation of the long line equations, methods of voltage control, Ferranti effect, incident, reflected and refracted waves, surge impedance and surge impedance loading of long lines, wave length and velocity of propagation of waves, representation of long lines, equivalent T and equivalent π network model, numerical problems.

UNIT-III	OVERHEAD INSULATORS AND UNDERGROUND CABLES

Overhead insulators: Types of insulators, voltage distribution, string efficiency and methods for improvement, capacitance grading and static shielding, numerical problems.
Underground cables: Types of cables, construction, types of insulating materials, calculations of insulation resistance and stress in insulation, capacitance of single and three core belted cables, grading of cables, capacitance grading, description of inter sheath grading, numerical problems.

UNIT-IV	MECHANICAL DESIGN OF TRANSMISSION LINES

Sag and tension calculations: Sag and tension calculations with equal and unequal heights of towers, effect of wind and ice on weight of conductor, stringing chart and sag template and its applications, numerical problems.

UNIT-V	DISTRIBUTION SYSTEMS

Distribution systems: Classification, comparison of DC vs AC and underground vs overhead, radial and ring main system, requirements and design features, Substation: Substation design, equipments, types of substations, bus bar arrangement layout, bus schemes, location, Kelvin's law for the design of feeders and its limitations; voltage drop calculations in DC distributors: Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor, voltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages, numerical problems; Basic concept of interconnected systems: Indian electricity rules, various voltage levels of transmission and distribution systems, Indian grid scenario.

| **Text Books:** |
| 1. C L Wadhwa, "Electric Power Systems", New age publications, New Delhi, 9th Edition, 2007. |
| 2. Singh S N, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2002. |
| 3. Turan Gonen, "Electrical Power Distribution System Engineering", CRC Press, 3rd Edition, 2014. |
| 4. V Kamaraju, "Electrical Power Distribution Systems", TMH, Publication, Edition 2009. |
| **Reference Books:** |
| 1. J B Gupta, "A Course in Power Systems", S K Kataria and Sons, 2013 Edition, 2013 |
| 2. D Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007. |
| 3. V K Mehta and Rohit Mehta, "Principles of Power System", S Chand, 3rd revised Edition, 2015. |
| 4. M L Soni, P V Gupta, U S Bhatnagar and A Chakrabarthy, "A Text Book on Power System Engineering", Dhanpat Rai and Co Pvt. Ltd., revised Edition, 2009. |

XVI. COURSE PLAN:

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

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	List out the types of conductors	CLO 1	R1:1.1-1.4, 2.2-2.7
3	Show the simple diagrams of typical towers and conductors for 400, 220 and 132 kV operations	CLO 2	R1:2.3
4	Calculate the resistance of solid conductors, numerical problems	CLO 3	R1: 5.2
5	Compute the inductance of single phase single circuit lines and double circuit lines	CLO 2	T1:2.1-2.5
6	Calculate the inductance of three phase single circuit lines and explain the concept of GMR and GMD	CLO 3	T1:2.6
7	Determine the inductance of three phase double circuit lines, concept of GMR and GMD symmetrical conductor without configuration transposition, numerical problems	CLO 3	T1:2.9- 2.10
8	Compute the inductance of three phase double circuit lines, concept of GMR and GMD symmetrical conductor without configuration , numerical problems	CLO 4	T1:2.9- 2.10
9-11	Determine the capacitance of single phase lines, single circuit and double circuit lines. symmetrical three phase lines, single circuit lines, asymmetrical three phase lines, single and double circuit lines	CLO 4	T1:3.1-3.6
12	Illustrate the effect of ground on capacitance. Numerical problems	CLO 4	T1:3.7
13	Describe the effect of corona.	CLO 5	T1:6.2
14	Interpret the critical disruptive voltages, factors affecting corona	CLO 5	T1:6.1
15	List out the methods for reducing corona power loss, charge voltage diagram	CLO 6	T1:6.2-6.3
16	Predict the audible noise, radio interference with corona effect.	CLO 6	T1:6.5
17	Classify the types of transmission lines: Short, medium and long line and their model representations	CLO 5	T1:4.1
18	Demonstrate the performance of short transmission lines	CLO 7	T1:4.2
19	Explain nominal T and A, B, C, D constants for symmetrical and asymmetrical networks for medium transmission lines .	CLO 7	T1:4.3

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
20	Estimate the regulation and efficiency of all types of lines by mathematical solutions	CLO 7	T1:4.3
21-23	Interpret the Long transmission line: Rigorous solution, evaluation of A, B, C, D constants, interpretation of the long line equations, Ferranti effect	CLO 7	T1:4.4-4.5
24	List out the methods of voltage control	CLO 9	T1:10.1- 10.2
25-27	Discuss the incident, reflected and refracted waves, surge impedance and surge impedance loading of long lines	CLO 9	T1:12.4
28	Examine the wave length and velocity of propagation of waves	CLO 9	T1:12.4
29	Represent the long lines in terms equivalent T and equivalent π network model.	CLO 9	T1:4.4
30	Classify the types of insulators	CLO 8	T1:8.1
31-33	Determine the voltage distribution in a string of insulators , string efficiency	CLO 10	T1:8.2
34-36	Identify the methods(capacitance grading and static shielding) for improvement of string of insulators	CLO 10	T1:8.3
37	Classify the types of cables based on construction.	CLO 10	T1:9.9
38-39	Explain the construction, types of insulating materials, calculations of insulation resistance and stress in insulation.	CLO 11	T1:9.4-9.5
40	Determine the capacitance of single and three core belted cables,	CLO 11	T1:9.5
41-43	Illustrate the concept of grading (capacitance grading, description of inter sheath grading) of cables.	CLO 10	T1:9.3
44-47	Calculate the Sag and tension with equal and unequal heights of Towers	CLO 11	T1:7.2
48	Interpret the effect of wind and ice on weight of conductor	CLO 12	T1:7.3
49-50	Sketch the stringing chart and sag template and list out its applications	CLO 12	T1:7.4-7.5
51	Compare the DC vs AC and underground vs overhead, radial and ring main system and classify the types of distribution systems.	CLO 12	R1:1.4-1.5
52	Describe the requirements and design features of distribution systems.	CLO 12	R1:17. 5-17.7
53	Explain substation design, equipments, types of substations	CLO 13	R1: 17.9
54	Describe the bus bar arrangement layout, bus schemes	CLO 13	R1:17.9
55	Explain Kelvin's law for the design of feeders and its limitations	CLO 13	R1:P2
56	Calculate the voltage drop in DC distributors	CLO 14	R1: 9.2-9.7
57-58	Determine the voltage drop in Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor	CLO 14	R1:9.9
59	Determine the voltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages, numerical problems	CLO 14	R1:10.1-10.3
60	Discuss the basic concept of interconnected systems: Indian electricity rules, various voltage levels of transmission and distribution systems, Indian grid scenario.	CLO 14	R1:1.1 1-1.12

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

S No	Description	Proposed Actions	Relevance With POs	Relevance With PSOs
1	Modeling and implementation of Transmission lines	Project work in PSCAD	PO2,PO4	PSO1
2	Distribution feeders and substation	Visiting nearby substation	PO3,PO4	PSO1

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