INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**Fundamentals of HVDC and FACTS devices**			
Course Code	**A80237**			
Regulation	**R13**			
Course Structure	**Lectures**	**Tutorials**	**Practicals**	**Credits**
	4	**-**	**-**	**4**
Course Coordinator	**Dr. P Mallikarjun Sharma, Professor**			
Team of Instructors	**Ms. B. Manogna, Assistant Professor**			

I. COURSE OVERVIEW:

This subject deals with the importance of HVDC transmission, analysis of HVDC Converters, Harmonics and Filters, Reactive power control and Power factor improvements of the system. It also deals with basic FACTS concepts, static shunt and series compensation and combined compensation techniques.

II. PREREQUISITES:

Level	Credits	Periods	Prerequisite
UG	4	4	Power systems, High voltage engineering, and Power electronics.

III. COURSE ASSESSMENT METHODS:

a) Marks distribution:

Session Marks	University End Exam Marks	Total Marks
There shall be two mid tem examinations. Each midterm 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 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.	75	100

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 OBJECTIVES:

The course should enable the students to:

I	Summarize the different types of HVDC Transmission systems.
II	Distinguish AC and DC transmission system.
III	Examine the control schemes for HVDC transmission systems.
IV	Illustrate the power flow analysis of AC and DC systems.
V	Classify different types of FACTS devices which are used in compensation of reactive power.
VI	Analyze the Static series and combined compensators.

VI. COURSE OUTCOMES:

Students, who complete the course, will have demonstrated the ability to do the following:

1	Illustrate the layout of HVDC converter stations.
2	Demonstrate the rectifier and inverter configurations of 12 pulse HVDC converter.
3	Classify different FACTS controllers and their operation.
4	Analyze the power flow in HVDC systems.
5	Describe the converter control characteristics of HVDC systems.
6	Analyze the Harmonics and use of filters to minimize the harmonics.
7	Design AC and DC converters.
8	Summarize different FACTS devices to compensate reactive power.
9	Explain the necessity of Static series and combined compensators.
10	Discuss the principle of operation of unified power flow controller.

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.	S	Design/Exercises
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	Seminar
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.	N	-------
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	S	Discussions
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.	S	Seminars, Discussions
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.	S	Workshops
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: Comparison of AC-DC transmission systems, application of DC transmission, types of DC links, typical layout of HVDC converter station. HVDC converters, pulse number, analysis of Gratez circuit with and without overlap, converter bridge characteristics, equivalent circuits or rectifier and inverter configurations of twelve pulse converters

UNIT II:

Converter & HVDC system control: Principles of DC Link control, converter control characteristics, system control hierarchy, firing angle control, current and excitation angle control, starting and stopping of DC Link.

UNIT III:

Harmonics, Filters and Reactive power control: Introduction, generation of harmonics, AC and DC Filters, Reactive power Requirements in steady state, sources of reactive power, static VAR systems.

Power flow analysis in AC/DC systems: Modeling of DC/AC converters, controller equations, solutions of AC/DC load flow, simultaneous method, Sequential method.

UNIT IV:

Introduction to FACTS: Flow of power in AC Parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers.

Static shunt compensators: Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM.

UNIT-V:

Static Compensators: Objectives of Series compensation, Variable impedance type and thyristors switched series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC), power angle characteristics, basic operating control schemes.

Combined Compensators: Introduction, unified power flow controller (UPFC), basic operating principle, independent real and reactive power flow controller, control structure.

TEXT BOOKS:

1 HVDC Transmission systems, S Kamakshaiah, V. Kamaraju, The Mc Graw Hill Companies.

2 Understanding FACTS, Concepts and Technology of Flexible AC Transmission systems, Narain. G. Hingorani, Laszlo Gyugyi, IEEE press, Wiley India.

REFERENCES:

1 HVDC and FACTS Controllers applications of static converters in power systems, Vijay K. sood, Kluwer Accademic Publishers.

2 HVDC Power transmission systems, K R Padiyar, New Age International.

3 Thyristor Basd Controllers for Electrical Transmission Systems, R. Mohan Mathur, Rajiv K. Varma. Wiley India.

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Learning Objectives	Topics to be covered	Reference
1	To understand Economics of HVDC transmission	Economics of HVDC transmission system	T1:1.3.1
2	To know terminal equipment of HVDC	terminal equipment of HVDC transmission system	T1: 1.2
3-4	To classify the types of HVDC Links	types of HVDC Links	T1: 1.1
5	To know Apparatus required for HVDC	Apparatus required for HVDC system	T1 :2.1
6	To understand Comparison of AC and DC Transmission	Comparison of AC transmission and DC Transmission	T1: 1.3
7	To understand Application of DC transmission system	Application of DC transmission system	T1: 1.4
8	To know Modern trends	Modern trends in DC transmission	T1: 1.2
9	To understand analysis of GRAETZ	analysis of GRAETZ	T1:3.1-3.3
10	To understand 6 pulse converter unit	Characteristics of 6 Pulse converter	T2:2.3
11-12	To understand Characteristics of 12 pulse converter	Characteristics of 12 pulse converter	T2:2.11
13	Desired features of 3 phase converters	Case of two 3 phase converters in star	T2: 2.10.6
14	To understand 3 phase converters performance	Case of two 3 phase converters in star mode –their performance	T2: 2.10
15	To understand DC Link Control	Principle of DC Link Control	T1: 4.1-4.2
16-17	To understand Converter control characteristics	Converter control characteristics	T1: 4.3
18	To understand Firing angle control	Firing angle control	T1: 4.5-4.5.2
19	To understand current control, constant-extinction-angle control	Current and extinction angle control	T1 :4.6
20	To understand Effect of source inductance	Effect of source inductance on the system	T1:2.1

21	To understand Power Control	starting and stopping of Dc Link; Power Control	T1:4.8
22	To understand basic philosophy of system	Reactive power requirements in steady state	T2 : 4.1
23	To understand control strategies	conventional control strategies	T2: 4.2-4.3
24	To understand importance of reactive power	Sources of reactive power	T2 :4.4
25-26	To understand Ac Filters	Ac Filters	T1: 6.3
27-28	To understand Modeling of DC Links	Modeling of DC Links	T2: 5.1
29	To understand DC Network	DC Network-Dc converter-Controller Equations	T2 :5.1.3
30	To understand solution of Dc load flow	solution of Dc load flow	T2 : 5.2
31-32	To understand Solution of AC-DC power flow	Solution of AC-DC power flow	T2: 5.5
33	To understand Simultaneous method	Simultaneous method	T2: 5.5.1
34-35	To understand Sequential method	Sequential method	T2: 5.5.2
36	To understand Converter faults	Converter faults	T2: 6.1
37-38	To understand protection system	protection against over current and over voltage in converter station	T2 :6.3
39-40	To understand Generation of harmonics	Generation of harmonics ,	T1: 6.1
41	To understand characteristics harmonics, calculation of AC harmonics	characteristics harmonics, calculation of AC harmonics	T2:7.2
42-43	To understand Non characteristics of Harmonics, adverse effects of harmonics	Non characteristics of Harmonics, adverse effects of harmonics	T2: 7.6
44	To classify types of AC filters,	Types of AC filters,	T2: 8.2
45	Design of single tuned filters	Design of single tuned filters	T2: 8.3
46-47	Design of High pass filters	Design of High pass filters	T2: 8.5
48-49	Introduction to FACTS and power flow in AC parallel paths	FACTS and power flow in AC parallel paths	T3: 1.2
50	Basic types of FACTS devices	Basic types of FACTS devices	T3:1.7
51	To understand SVC	SVC	T3: 5.2.1
52-53	To understand STATCOM	STATCOM	T3:5.3
54	To understand shunt capacitors	shunt capacitors	T3: 5.1
55-56	To understand the series and variable impedance type compensators	series and variable impedance type compensators	T3: 5.5
57-58	To Understand TCSC	TCSC	T2:6.2.2
59	To Understand SSSC	SSSC	T2: 6.3.1
60	To Understand UPFC	UPFC	T3: 8.2

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

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I	-	S	S	-	-	S	S	-	-	-	-	-	S	-	-
II		S	H	-	-	-	-	-	-	-	-	-	H	-	-
III	H	H	S	-	-	-	-	-	-	-	-	-	S	-	-
IV	H	-	-	S	H	-	-	-	-	-	-	-	H	-	-
V	-	S	-	S	H	-	-	-	-	-	-	-	-	-	S
VI	-	S	-	S	H	-	-	-	-	-	-	-	-	-	S

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	S	-	H	-	-	S	-	-	-	-	-	-	H	-	-
2	H	-	H	-	-	-	-	-	-	-	-	-	H	-	-
3	-	S	H	-	-	S	-	-	-	-	-	-	S	-	-
4	H	S	-	-	-	-	-	-	-	-	-	-	H	-	-
5	S	-	-	H	-	-	-	-	-	-	-	-	S	-	-
6	S	S	H	-	-	-	-	-	-	-	-	-	S	-	-
7	S	-	H	-	-	-	-	-	-	-	-	-	S	-	-
8	H	-	H	-	-	-	-	-	-	-	-	-	S	-	-
9		H	S	-	-	S	-	-	-	-	-	-	-	-	S
10	S		H	-	-	S	-	-	-	-	-	-	-	-	S

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