FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2022-23

Programme: **Bachelor of Technology (Electrical Engineering)**

Semester: **VI**

Course Code: **202050608**

Course Title: **Fundamentals of HVDC and FACTS Devices**

Course Group: **Professional Elective Course -II**

Course Objectives: This course is taught at the UG level and focuses on the many operational and configurational aspects of HVDC transmission systems. For interconnected HVDC systems, the control approach for frequency and voltage regulation in DC links is detailed. It also deals with basic FACTS concepts, static shunt and series compensation and combined compensation techniques.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Theory		J/V/P*		Total
Lecture	Tutorial	Practical		Internal	External	Internal	External	
3	0	2	4	50 / 18	50 /17	25 / 09	25 / 09	150 / 53

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr.	Contents	Hours
1	**Introduction:** Comparison of AC and DC transmission systems, applications of DC transmission, limitation of HVDC transmission lines, types of DC links, typical layout of a HVDC converter station, HVDC converters, pulse number, analysis of Graetz circuit with and without overlap, converter bridge characteristics, equivalent circuits of rectifier and inverter configurations for twelve pulse converters.	09
2	**Converter & HVDC System Control:** Principal of DC link control –Converters control characteristics- system control hierarchy, firing angle control, current and excitation angle control, starting and stopping of DC link	07

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3	**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.	**04**
4	**Power Flow Analysis in AC/DC Systems:** Modeling of DC/AC converters, controller equations-solutions of AC/DC load flow-simultaneous method, sequential method.	**05**
5	**FACTS Concepts and General System Considerations:** Flow of power in AC parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers, Checklist of Possible Benefits from FACTs Technology.	**04**
6	**Static Shunt and Series Compensators:** **A. Static Shunt Compensators** Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM **B. Static Series Compensators** Objectives of series compensation, variable impedance type- thyristor controlled series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC)- External Control for series reactive Compensator.	**09**
7	**Combined Compensators:** Introduction, unified power flow controller (UPFC), basic operating principle, independent real and reactive power flow controller, Comparison of UPFC to series Compensators control structure.	**04**

List of Practicals / Tutorials:

1	Modeling and Simulation of uncontrolled and controlled rectifiers.
2	Modeling and simulation of Single Phase inverter with R, RL load.
3	Modeling and simulation of Three Phase inverter with R, RL load.
4	To study Simulation of 6 Pulse Converter in R, RL load Configuration.
5	To study Simulation of 12 Pulse Converter in R,RL load Configuration
6	To study Simulation of 18 Pulse Converter in R,RL load Configuration
7	Mathematical Analysis of 6 Pulse, 12 Pulse and 18 Pulse Converter.
8	Mathematical analysis of HVDC transmission line.
9	To study Simulation of HVDC transmission line.
10	To study simulation of Voltage Source Converter.
11	To study simulation of Current Source Converter
12	To study and Simulation of Series Compensation in transmission line.
13	To study and Simulation of Shunt Compensation in transmission line.
14	To study and simulation of SVC.

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15	To study and simulation of STATCOM.

Reference Books:

1	S Kamakshaiah, V. Kamaraju, "HVDC Transmission Systems", TMH Publications, 2011.
2	J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3	K R Padiyar, "HVDC Power transmission systems", New Age International Publishers, 2011.
4	E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley- Inder-science, 1971.
5	Narain. G. Hingorani, Laszlo Gyugyi, "Understanding FACTS, Concepts and Technology of Flexible AC Transmission systems", IEEE press, Wiley India.
6	Vijay K. sood, "HVDC and FACTS Controllers- applications of static converters in power systems", Springer publication.

Supplementary learning Material:	
1	https://electrical-engineering-portal.com/
2	https://www.electrical4u.com/
3	https://nptel.ac.in/courses/108107114
4	https://nptel.ac.in/courses/108104013

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits
- Course Projects

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks in %						**R**: Remembering; **U**: Understanding; **A**: Applying; **N**: Analyzing; **E**: Evaluating; **C**: Creating
R	**U**	**A**	**N**	**E**	**C**	
30%	30%	20%	10%	10%	0%	

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

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Course Outcomes (CO):

Sr.	Course Outcome Statements	%Weightage
CO-1	Understand the advantages of DC transmission over AC transmission.	**20%**
CO-2	Analysis of Line Commutated Converters and Voltage Source Converters in HVDC Transmission System.	**30%**
CO-3	Application of suitable control strategies used for LCC and VSC based HVDC transmission system.	**15%**
CO-4	Choose proper FACTS controller for the specific application based on system requirements.	**15%**
CO-5	Analyze the control circuits of Shunt Controllers, Series controllers & Combined controllers for various functions.	**20%**

Curriculum Revision:	
Version:	**2.0**
Drafted on (Month-Year):	Jun-2022
Last Reviewed on (Month-Year):	
Next Review on (Month-Year):	June-2025

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