

HVDC TRANSMISSION

I Semester: EPS									
Course Code	Category	Hours / Week			Credits	Maximum Marks			
BPSB03	Elective	L	T	P	C	CIA	SEE	Total	
		3	-	-	3	30	70	100	
Contact Classes:45		Tutorial Classes: Nil			Practical Classes: Nil			Total Classes: 45	

COURSE OBJECTIVES:

The course should enable the students to:

- I. Understand state of the art HVDC technology
- II. Learn the methods to carry out modeling and analysis of HVDC system frontier-area power flow regulation

COURSE OUTCOMES (COs):

- CO 1: Classify AC and DC transmission and understand control characteristics of HVDC system.
- CO 2: Explain the working of HVDC converter in rectifier and inverter modes of operation.
- CO 3: Understand different control schemes used in HVDC converters
- CO 4: Understand the nature of faults happening on both the AC and DC sides of the converters and formulate protection schemes for the same.
- CO 5: Develop harmonic models and use the knowledge of circuit theory to develop filters and assess the requirement and type of protection for the filters.

COURSE LEARNING OUTCOMES (CLOs):

1. Illustrate the layout of HVDC converter stations.
2. Understand the difference between HVDC and HVAC transmission
3. Describe the converter control characteristics of HVDC systems.
4. Analyze single phase and three phase converters and understand its properties
5. Demonstrate the rectifier configurations of 12 pulse HVDC converter.
6. Understand the working of inverter configuration of HVDC converter.
7. Understand different modes of operation of converters.
8. Analyze the output waveforms for rectifier and inverter circuits
9. Examine the control schemes for HVDC transmission systems.
10. Analyze the characteristics of HVDC converter with respect to Constant current and Constant voltage
11. Understand actual and desired characteristics of a converter
12. Understand the concept of power reversal in HVDC converters
13. Illustrate the starting and stopping of converter bridge
14. Analyze various aspects responsible for commutation failure
15. Analyze the adverse effects of HVDC converter on equipment
16. Understand different methods used in protection of HVDC converter
17. Understand controllers for controlling the power flow through a dc link
18. Analyze the Harmonics and use of filters to minimize the harmonics.
19. Understand the importance of smoothening reactors in HVDC converters
20. Analyze the harmonics and basis of protection for HVDC System.

UNIT- I	GENERAL ASPECTS OF HVDC TRANSMISSION	Classes: 09
Evolution of HVDC transmission, comparison of HVDC and HVAC systems, types of DC link, components of HVDC system, value characteristics, properties of converter circuits, assumptions, single phase and three phase converters, pulse number, choice of best circuit for HVDC converters.		
UNIT - II	ANALYSIS OF BRIDGE CONVERTER	Classes: 09
Analysis of simple rectifier circuit, required features of rectification circuits for HVDC transmission, Analysis of HVDC converter, different modes of converter operation, output voltage waveform and DC voltage in rectification, output voltage waveforms and DC in inverter operation, thyristor/ valve voltages, equivalent electrical circuit.		
UNIT - III	HVDC CONTROL TECHNIQUES	Classes: 09
Grid control, basic means of control, power reversal, limitations of manual control, constant current versus constant voltage, desired features of control, actual control characteristics. Constant minimum ignition angle control: Constant current control, constant extinction angle control, stability of control, tap changer control, power control and current limits, frequency control.		
UNIT - IV	CONVERTER FAULTS AND PROTECTION	Classes: 09
Converter mal-operations, commutation failure, starting and shutting down the converter bridge, converter protection.		
UNIT - V	REACTIVE POWER MANAGMENT	Classes: 09
Smoothing reactor and DC Lines, reactive power requirements, harmonic analysis, filter design, power flow analysis in AC, DC systems, modeling of DC links, solutions of AC, DC Power flow.		
Text Books:		
<ol style="list-style-type: none"> 1. JArrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1st Edition, 1983. 2. K R Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1st Edition, 1990. 		
Reference Books:		
<ol style="list-style-type: none"> 1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1st Edition, 1971. 2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 1st Edition, 2004. 3. SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd Edition, 2008. 4. V Kamaraju, "HVDC Transmission" Tata McGraw-Hill Education Pvt Ltd, New Delhi, 2nd Edition, 2011. 		
Web References:		
<ol style="list-style-type: none"> 1. https://www.rceroorkee.in/pdf/pdfo/tee033.pdf 2. https://www.books.google.com/books?id=e24fndv2aroc 3. https://www.nptel.ac.in/syllabus/108108033/ 		
E-Text Books:		
<ol style="list-style-type: none"> 1. https://www.site.uottawa.ca 2. https://www.galerybooks.com 3. https://www.jntubook.com/ 		