

Branch Name:	Electrical Engineering
Program Code:	ET109
Course Name:	Department Elective-II: HVDC Transmission Systems
Course Code:	1ET1090707
Pre-requisite Course:	Basic understanding of structure of the power system and power system analysis

Course Objectives:

1. This subject deals with the fundamentals for HVDC conversion technologies.
2. HVDC converter configurations.
3. This subject highlights the behavior of uncompensated and compensated transmission lines.
4. Students will get basic concepts about various reactive power compensators.

Teaching and Examination Scheme:

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)								
Lecture	Tutorial	Practical	Credit	Theory				Practical				Total
				University Assessment		Continuous Assessment		University Assessment		Continuous Assessment		
				Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
3	-	-	3	28	70	12	30	-	-	-	-	100

Course Contents:

Sr. No.	Topic	Total Hours	Weightage (%)
1	HVDC Transmission-Development: Introduction, Historical Development, Advantages and Disadvantages of DC transmission, Limitation of HVDC, Equipment required for HVDC System, Comparison of AC and DC transmission, Kinds of DC links and its applications, Reliability of HVDC Systems, Comparison of HVDC link with EHV AC link, HVDC-VSC Transmission System.	10	24
2	HVDC Converters: Introduction, Insulated Gate Bipolar Transistor (IGBT), HVDC Converter Valve and Valve Assembly, HVDC –VSC Operation and Principles, Three Phase Six Pulse Converter using SCRs, Twelve Pulse Bridge Converters.	08	20
3	Harmonics and Filters in HVDC Systems: Introduction, Measurement of DC current, voltage, power, Sources of reactive power, Importance of Harmonic Study, Generation of AC harmonics, Generation of DC harmonics, Generation of Characteristic Harmonics and uncharacteristic harmonics, HVDC Filters: DC filters on Inverter side and AC filters on Rectifier side.	10	24
4	Reactive Power Control in Electrical Power Transmission Systems: Background, Conventional Control Mechanisms, Automatic Generation Control (AGC), Excitation Control, Transformer Tap-Changer Control, Phase Shifting Transformers, Characteristics of Uncompensated Transmission	05	12

	Lines, A simple Case, Lossless Distributed Parameter Lines, Passive Compensation, Shunt Compensation, Series Compensation, Effect on power-Transfer Capacity, Series Compensation, Shunt Compensation.		
5	Principles of Conventional Reactive Power Compensators: Introduction, Synchronous Condensers, The saturated Reactor, Thyristor Controlled Reactor (TCR), Operating Characteristics of a TCR, The Fixed Capacitor Thyristor Controlled Reactor (FC-TCR)-Configuration and Operating Characteristic, The Mechanically Switched Capacitor-Thyristor Controlled Reactor (MSC-TCR), The Thyristor-Switched Capacitor (TSC)-The TSC Configuration and Operating Characteristic, The Thyristor-Switched Capacitor-Thyristor-Controlled Reactor (TSC-TCR)- Configuration and Operating Characteristics, Comparison of different SVCs.	08	20

Reference Books:

1. Thyristor-Based FACTS Controllers for Electrical Transmission Systems-R.M.Mathur/ R.K.Verma, John Wiley & Sons, Inc., 2012.
2. N. Hingorani, L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC transmission Systems, Delhi Publishers, 2009.
3. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
4. Vijay K Sood, "HVDC and FACTS Controller" Springer Publication, 2004.
5. S Kamakshaiah and V Kamaraju, "HVDC Transmission" TMH Publications, 2011.

List of Open Source Software/learning website:

- <http://nptel.ac.in/courses>
- <http://www.electrical-engineering-portal.com/>
- <http://nptel.iitm.ac.in/courses.php>

Course Learning Outcomes (CLO): On completion of this course, the students will be able to:

CLO	Description	Bloom's Taxonomy Level
CLO1	Understand the advantages of dc transmission over ac transmission.	2 Understanding
CLO2	Analysis of Line Commutated Converters and Voltage Source Converters in HVDC Transmission System.	4 Analyzing
CLO3	Application of suitable control strategies used for LCC and VSC based HVDC transmission system.	3 Applying
CLO4	Evaluation of Power system angular, voltage and frequency stability using simulation models for various configuration of an HVDC system.	5 Evaluating
CLO5	The students will acquire the knowledge regarding the different configuration of HVDC converters.	1 Remembering
CLO6	Understand the significance of reactive power compensators and it's applications.	2 Understanding

Mapping of CLOs with POs & PSOs

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcomes(PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO1	L	M					L		L		M				M	
CLO2	H		M		L		M					M				L
CLO3				L	M	L		L		M				L		
CLO4		L						M	L							
CLO5				L		H	M						L			M
CLO6		L	L	H	M					H	M			M		

H: High, M: Medium, L: Low