

## HVDC TRANSMISSION SYSTEMS

<b>Course Code</b>	19EE4701B	<b>Year</b>	IV	<b>Semester</b>	I
<b>Course Category</b>	Program Elective IV	<b>Branch</b>	EEE	<b>Course Type</b>	Theory
<b>Credits</b>	3	<b>L-T-P</b>	3-0-0	<b>Prerequisites</b>	
<b>Continuous Internal Evaluation</b>	30	<b>Semester End Evaluation</b>	70	<b>Total Marks</b>	100

### Course Outcomes

Upon successful completion of the course, the student will be able to	
CO1	<b>Identify</b> HVDC power terminal equipment, classify type of HVDC connectivity and planning of HVDC system.(L2)
CO2	<b>Understanding</b> the choice of pulse conversion, control characteristic, firing angle control.
CO3	<b>Interpret</b> different types of converter control techniques
CO4	Able to <b>calculate</b> voltage and current harmonics, and design of filters and understand the reactive power necessity of conventional control.
CO5	<b>Investigate</b> Protection requirements, factors affecting power flow analysis and <b>analyse</b> real-time system.

### Contribution of Course Outcomes towards achievement of Program Outcomes & Strength of correlations (3:High, 2: Medium, 1:Low)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2		2			2					2	2	2
CO2	3	2	2										2	2
CO3							2						2	2
CO4	3	2	2				2						2	2
CO5	2	2	2				2						2	2

### SYLLABUS

Unit No.	Contents	Mapped CO
I	<b>Basic Concepts of DC Transmission</b> Components of HVDC transmission systems: Types of HVDC Links – Comparison of AC & DC transmission – Application of DC Transmission System – Planning and Modern trends in DC transmission, HVDC light.	<b>CO1</b>
II	<b>Analysis of HVDC Converters</b> Choice of Converter configuration – Analysis of Graetz – Characteristics of 6 Pulse – converter operation –Equivalent circuit –12 Pulse converters configurations –Small HVDC tapping.	<b>CO2</b>
III	<b>Converter and System Control</b> Principle of DC Link Control – Individual phase control, Equidistant firing control Constant-current loop – Inverter extinction-angle control – Starting and stopping of DC-link – Power Control.	<b>CO3</b>

IV	<p><b>Harmonic analysis, Filters</b> – Characteristics and Non-Characteristics harmonics – Calculation of AC Harmonics —effects of harmonics – Calculation of voltage &amp; current harmonics – Effect of Pulse number on harmonics. Design of AC filters</p> <p><b>Reactive Power requirement</b> – Need of reactive power compensation in HVDC system, sources of reactive power.</p>	CO4
V	<p><b>Faults ,Protection and case study of HVDC system</b></p> <p>Converter faults–over current and over voltage protection in converter station –Case study of any existing HVDC link in India, Case study of any existing HVDC link in the world.</p> <p><b>Power flow analysis in AC/DC systems</b></p> <p>Component models, solution of DC load flow, Parallel operation of HVDC/AC systems, Multi-terminal systems.</p>	CO5

<b>Learning Resources</b>	
<b>Text Books:</b>	
<ol style="list-style-type: none"> <li>1. HVDC Power Transmission Systems: Technology and System Interactions – by K.R.Padiyar, New Age International (P) Limited, and Publishers.</li> <li>2. Direct Current Transmission – by E.W.Kimbark, John Wiley &amp; Sons</li> </ol>	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. HVDC Transmission – J. Arrillaga.</li> <li>2. Power Transmission by Direct Current – by E.Uhlmann, B.S.Publications.</li> </ol>	
<b>Learning Resources:</b>	
<a href="https://nptel.ac.in/courses/108/104/108104013/">https://nptel.ac.in/courses/108/104/108104013/</a> <a href="https://www.brown.edu/Departments/Engineering/Courses/ENGN1931F/HVDC_Proven_TechnologySiemens.pdf">https://www.brown.edu/Departments/Engineering/Courses/ENGN1931F/HVDC_Proven_TechnologySiemens.pdf</a>	