



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Electrical Engineering

Course / Subject Code: ME01000191

Course / Subject Name: HVDC - High Voltage Direct Current Transmission

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|-------------------------|--------------------------|
| w. e. f. Academic Year: | 2024-25 |
| Semester: | 1 st Semester |
| Category of the Course: | PEC |

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|----------------------|---|
| Prerequisite: | Power Electronics Converters and Applications Power Systems Analysis |
| Rationale: | The bulk power transmission from HVAC to HVDC has evolved over the years. The state of art of development of HVDC Technology, equipment used in HVDC its modeling analysis and control are covered. The stability study, control strategies and protection of power systems with HVDC transmission for reliable and secure operation of the power in the power systems are also covered. The course is intended to provide the technological development in HVDC it's theory and understanding for operation and control of power systems with HVDC transmission. |

Teaching and Examination Scheme:

| Teaching Scheme | | | Credits | Examination Marks | | | | Total Marks |
|-----------------|---|---|---------|-------------------|--------|-----------------|--------|-------------|
| L | T | P | | Theory Marks | | Practical Marks | | |
| | | | | ESE (E) | PA (M) | ESE (V) | PA (I) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 30 | 20 | 150 |

Content

| Sr. No. | Content | Total Hrs | % Weightage |
|---------|--|-----------|-------------|
| 1 | Evolution of HVDC Transmission, Comparison of HVAC and HVDC systems, Type of HVDC Transmission systems, Components of HVDC transmission systems. | 04 | 10 |
| 2 | Analysis of simple rectifier circuits: Required features of converter/inverter circuits for HVDC transmission, Analysis of HVDC converter, Different modes of converter operation, Equivalent electrical circuit | 09 | 20 |



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| 3 | HVDC system control features, Control Modes, Control Schemes, Control comparisons, Equidistant firing controls, | 05 | 10 |
| 4 | Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge, Converter protection, Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design | 06 | 14 |
| 5 | Application of VSC in HVDC, Comparison with LCC HVDC, Overhead and subsea VSC-HVDC, Monopolar and bipolar VSC HVDC systems, VSC HVDC converter topologies, VSC-HVDC components and operation, Two level VSC modelling, control and dynamics, Complete VSC converter controller, AC and DC faults with VSC, VSC HVDC for AC grid support and operation with passive AC systems, Black start capability of VSC-HVDC, VSC-HVDC with offshore wind farms, Multi terminal HVDC with VSC Converters, Introduction to MMC for HVDC. | 12 | 26 |
| 6 | Component Models and it's representation for the Power flow analysis of AC-DC systems, Transient stability analysis, Dynamic stability analysis, Multi-terminal HVDC system (MTDC), control of MTDC, Introduction to the relevant national and international standards of HVDC systems | 09 | 20 |
| TOTAL | | 45 | 100 |

Reference Books:

1. KR Padiyar, "HVDC Power Transmission Systems", Willey Eastern Limited, Second edition.
2. J Arrillaga, "High Voltage Direct current Transmission", Peter Peregrinus Ltd, UK.
3. EW Kimbark, "Direct Current Transmission", Wiley-Interscience, New York. 1971
4. Erich Uhlmann, Power Transmission by Direct Current, B. S. Publications 2004
5. SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi 2nd edition, 2008
6. Dragan Jovcic, High Voltage Direct Current Transmission: Converters, Systems and DC Grids, Wiley & Sons
7. Dirk Van Hertem, Oriol Gomis-Bellmunt, Jun Liang, HVDC Grids: For Offshore and Supergrid of the future, Wiley-IEEE Press
8. Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, Seok-Jin Lee, HVDC Transmission: Power Conversion Applications in Power Systems, John Wiley & Sons



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List of Experiments:

This is Just a Suggested list of Experiments. The teachers are encouraged to include the experiments from above topics.

1. Study and compare the basic topologies HVDC transmission
2. Study of basic topologies converter/inverter used for HVDC Power transmission
3. Modelling /Simulation of converter and it's analysis in various operating modes
4. Simulation and study of Real power flow control in AC-DC power systems
5. Simulation and study of Reactive power flow control in AC-DC power systems
6. Stability study of AC-DC power systems
7. Study of Standards of HVDC systems
8. Simulation of two terminal VSC HVDC systems in PSCAD/MATLAB.
9. Simulation of MTDC system in PSCAD/MATLAB.
10. Simulation of VSC/MMC HVDC system with OFFSHORE windfarms in PSCAD/MATLAB.
11. Design of harmonic filter for the HVDC systems
12. Simulation of smoothing reactor for HVDC transmission systems
13. Prepare a report/Visit on HVDC Project in Gujarat/India.
14. To design transformer used with half bridge converter/ full bridge converter
15. Automatic and manual synchronization of converter station with grid using appropriate simulation software
16. Three-phase display of grid and converter voltages using appropriate simulation software
17. Simulation of Control schemes for converter/inverter output voltage and frequency

Major Equipment:

The Software and hardware/Equipment used in the Power electronics and Power systems lab are sufficient for the performance of above practical.

List of Open Source Software/learning website:

<https://nptel.ac.in/courses/108104013>

<https://www.mathworks.com/>

<https://powersimtech.com>

<https://www.scilab.org/>
