# SCHEME OF COURSE WORK

**Course Details:**

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| **Course Title** | **: HIGH VOLTAGE DC TRANSMISSION** | | |
| **Course Code** | **: 13EE2207** | **L P C** | **:4 0 3** |
| **Program:** | **: Master of Technology.** | | |
| **Specialization:** | **: Power Electronics & Drives** | | |
| **Semester** | **: I** | | |
| **Prerequisites** | **:Power Transmission system, Power Electronics and Switchgear & Protection** | | |
| **Courses to which it is a prerequisite** | **: Research** | | |

**Course Outcomes (COs):**

After completion of this course the student will be able to

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| 1 | Analyze the complete operation of HVDC Converter stations |
| 2 | Analyze the harmonics behavior and Control of HVDC System |
| 3 | Analyze the interaction of HVAC and HVDC system |
| 4 | Analyze Series and Parallel MTDC and its Control |
| 5 | Analyze Over Voltage and Over Current Protection Schemes |

**Program Outcomes (POs):**

The Graduates of will be able to:

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| 1 | Develop in depth knowledge in the areas of "Static Power Electronics Converters", "Power Electronic Converter fed Electrical Drives" and "Power Quality" |
| 2 | Apply soft computing techniques for Power Electronic Systems and Electric Drives |
| 3 | Understand large scale Power Electronic Converter Systems, Electric Drives and issues involved through Modeling, Analysis and Simulation |
| 4 | Apply present day techniques and tools to solve Power electronic and electric drives problems relevant to India and other countries |
| 5 | Use state-of-the-art simulation tools such as PLEXIM, SABER, OPAL-RT Lab, DSPACE, MULTISIM, LABVIEW and other Tools |
| 6 | Contribute positively to collaborative and multidisciplinary research to achieve common goals |
| 7 | Demonstrate knowledge and understanding of power engineering and management principles and apply the same for efficiently carrying out projects with due consideration to economical and financial factors |
| 8 | Communicate confidently, make effective presentations and write good reports to engineering community and society |
| 9 | Recognize the need for life-long learning and have the ability to do it independently |
| 10 | Acquire knowledge on social issues and shall contribute to the community for sustainable development |
| 11 | Predict and examine critically the outcomes of actions, apply corrective measures subsequently and move forward positively through a self corrective approach |

**Course Outcome** Versus **Program Outcomes:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | S | S | S | S | S | M | M | | M | S | S |
| **CO-2** | S | S | S | S | S | S | M | | M | S | S |
| **CO-3** | S | S | M | S | S | S | M | | M | S | S |
| **CO-4** | S | S | M | S | S | S | M | | M | S | S |
| **CO-5** | S | S | M | S | S | S | M | | M | S | S |

*S* - Strongly correlated, *M* - *Moderately* correlated, *Blank* - *No correlation*

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| **Assessment Methods:** | Assignment / Quiz / Seminar / Case Study / Mid-Test / End Exam |

# Teaching-Learning and Evaluation

| Week | TOPIC / CONTENTS | Course Outcomes | Sample questions | TEACHING-LEARNING STRATEGY | Assessment Method & Schedule |
|---|---|---|---|---|---|
| 1 | Evolution of HVDC Transmission.<br>Comparison of HVAC and HVDC systems.<br>Type of HVDC Transmission systems.<br>Components of HVDC transmission systems. | CO-1 | Compare HVAC and HVDC in all aspects<br>Types of HVDC Systems<br>What are the different components of HVDC Systems<br>Modern Trends HVDC Systems | ▫ Lecture through Black Board & LCD<br>▫ Discussion | Seminar/Mid Test (Week 9-10) |
| 2 | Analysis of simple rectifier circuits.<br>Required features of rectification circuits for HVDC transmission | CO-1 | Required Features of HVDC Converter | ▫ Lecture through Black Board & LCD<br>▫ Discussion | Seminar/Mid Test (Week 9-10) |
| 3 | Analysis of HVDC converter.<br>a. Different modes of converter operation.<br>b. Output voltage waveforms and DC voltage in rectification. | CO-1 | Analyze the Greatz Circuit<br>Analyze the Rectifier Voltage and Valve Voltages | ▫ Lecture through Black Board & LCD<br>▫ Problem solving | Seminar/Mid Test (Week 9-10) |
| 4 | Analysis of HVDC converter<br>a. Output voltage waveforms and DC in inverter operation.<br>b. Thyristor voltages.<br>Equivalent Electrical Circuit of HVDC | CO-1 | Analyze the 12 Pulse Converter<br>With necessary Diagrams and equations derive the Equivalent Circuit of HVDC System | ▫ Lecture through Black Board & LCD<br>Problem solving | Seminar/Mid Test (Week 9-10) |
| 5 | Smoothing reactor and DC Lines.<br>Reactive power requirements. | CO-2 | What is the need for Requirement of Reactive Power<br>Write about different types of Reactive Power sources | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 9-10) |
| 6 | Harmonic analysis.<br>Filter design | CO-2 | How harmonics are generated and what are the different Harmonics present in HVDC system and how are they eliminated | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 9-10) |
| 7 | HVDC system control features.<br>Control Modes.<br>Control Schemes.<br>Control comparisons | CO-2 | Explain the different control Strategies applied for HVDC system<br>Explain and differentiate about the IPC and EPC modes of Firing | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 9-10) |
| 8 | Need of Interaction between HV AC and DC System Strength | CO-3 | What is the need of interaction between HV AC/DC Systems<br>Write a short note non System Strength | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 9-10) |
| **9** | **Seminar by the Students** | | | | Seminar (Week 9) |
| 10 | **Mid-Test 1** | | | | |
| 11 | Interaction between HV AC and DC<br>Voltage Interaction<br>Power Flow Modulation | CO-3 | What do infer by the word Voltage Interaction<br>How power flow takes place in HVDC system<br>What are the different Harmonic Instabilities in HVAC/DC interaction | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 12 | Multi-terminal HVDC system.<br>Advances in HVDC transmission. | CO-4 | what is the need for Multi Terminal DC System<br>what are the different Types of MTDC systems<br>Compare Series & Parallel MTDC Systems in Detail. | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 13 | HVDC system application in wind power generation | CO-4 | How can we integrate HVDC System with Wind Generation | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 14 | Transient over voltages in HVDC systems<br>Dc side over voltages<br>Ac side over voltages. | CO-5 | How can we protect HVDC System from Over Voltages | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 15 | Converter mal-operations.<br>Commutation failure.<br>Starting and shutting down the converter bridge | CO-5 | What are the different Converter Mal-operation in Detail<br>Wht is the Procedure for Starting and shutting down the converter bridge | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 16 | Over Current Protection<br>Converter protection.<br>Surge Arrestors | CO-5 | How can we protect HVDC System from Over Currents.<br>Write a short note on DC Breakers | ▫ Lecture through Black Board & LCD<br>Discussion | Seminar/Mid Test (Week 17-18) |
| 17 | **STUDENTS SEMINAR** | | | | Seminar (Week 17) |
| **18** | **Mid-Test 2** | | | | |
| **19/20** | **END EXAM** | | | | |