EEPE3010 HIGH VOLTAGE ENGINEERING (3-0-0)

Course Learning Objectives: This course will enable students to:

- Understand electric field distribution, insulation systems, and dielectric materials used in high-voltage apparatus.
- Analyze breakdown mechanisms in gaseous, liquid, solid, and composite dielectrics.
- Explain methods of generating high AC, DC, impulse voltages, and high currents.
- Understand measurement techniques for high voltages and currents using conventional and digital methods.
- Evaluate high-voltage testing procedures, insulation coordination, and safety standards in power systems.

Module I (4 Hours)

Introduction to High Voltage Engineering and Insulation Systems:

Introduction to high voltage engineering, importance and applications, electric field stresses, estimation and control, geometrical, resistive and capacitive grading; insulation engineering, gaseous, liquid, solid and composite dielectrics; insulation systems for power apparatus such as transformers, cables, circuit breakers, bushings and rotating machines.

Module II (7 Hours)

Breakdown in Dielectric Materials:

Breakdown in dielectrics, ionization processes, Townsend's criterion, Paschen's law, streamer mechanism; breakdown in electronegative gases and non-uniform fields, time lag for breakdown; conduction and breakdown in liquid dielectrics, pure and commercial liquids, suspended particle mechanism; breakdown in solid dielectrics, intrinsic, thermal and electromechanical breakdown, ageing and deterioration of insulation; breakdown in composite and nano-filled dielectrics.

Module III (6 Hours)

Generation of High Voltages and Currents:

Generation of high voltages, high alternating voltages using cascaded transformers and series resonance circuits; high direct voltages using voltage doubler or multiplier circuits and electrostatic generators; generation of impulse voltages, single and multistage impulse generators, wave shaping, triggering and control; generation of impulse currents and switching surges; simulation and modeling of high voltage generation circuits.

Module IV (6 Hours)

Measurement of High Voltages and Currents:

Measurement of high voltages, sphere gap method, factors affecting accuracy, correction factors; resistive and capacitive voltage dividers; generating voltmeters and electrostatic voltmeters; measurement of impulse voltages using capacitive dividers and CROs; measurement of high currents, resistive shunts, Hall effect sensors, Rogowski coils; digital measurement systems, digital storage oscilloscopes and transient recording.

Module V (7 Hours)

Testing and Insulation Coordination:

Testing and insulation coordination, non-destructive testing of insulation, partial discharge and dielectric loss measurements, ageing and life estimation; high voltage testing of power apparatus such as insulators, bushings, cables, transformers, circuit breakers and surge arresters; impulse testing of transformers, test circuits and waveform analysis; over voltages in power systems, lightning and switching surges; principles of insulation coordination and safety standards in EHV systems.

Course Outcomes (CO): On completion of this course, students are able to:

CO1. Explain fundamentals and applications of high voltage engineering and insulation systems.
CO2. Analyze breakdown mechanisms in gaseous, liquid and solid dielectrics.
CO3. Describe methods of generation of high alternating, direct and impulse voltages and currents.

CO4. Select techniques and instruments for high voltage and transient current measurements.
CO5. Evaluate insulation performance and apply principles of insulation coordination and testing.

Text Book(s):

1. M. S. Naidu and V. Kamaraju, High Voltage Engineering, 5th ed., New Delhi, India: McGraw Hill Education, 2020.
2. E. Kuffel, W. S. Zaengl, and J. Kuffel, High Voltage Engineering: Fundamentals, 2nd ed., Oxford, U.K.: Elsevier/Newnes, 2000.

Reference Book(s):

1. C. L. Wadhwa, High Voltage Engineering, 4th ed., New Delhi, India: New Age International, 2018.
2. D. Kind and K. Feser, High Voltage Test Techniques, 2nd ed., Oxford, U.K.: Butterworth-Heinemann, 2001.
3. R. Arora and W. Mosch, High Voltage and Electrical Insulation Engineering, Hoboken, NJ, USA: Wiley-IEEE Press, 2011.