High Voltage Engineering

**Course Objective:**  
After the completion of this course the student will get through knowledge for

1. different causes and types of over voltages
2. breakdown mechanisms for gaseous, liquid and solid dielectrics
3. HVAC/HVDC and impulse  testing of In sulation
4. safety against high voltage
5. **Evolution of power system [6 hours]**
   1. Classification of High voltages
   2. Emerging Trends in Power Systems
   3. High voltage AC and HVDC systems
   4. basic introduction to FACTS devices
   5. High voltage power cables AC and DC

1. **Electric shocks [6 hours]**
   1. Physiological effects of electric shock, ventricular fibrillation
   2. First aid for electric shock
   3. Safety precautions and regulations
   4. Earthing and shielding techniques for personnel and equipment protection
   5. Measurements of earth resistivity and earth resistance

1. **Over voltages in power system [8 hours]**
   1. Classification of over voltages; temporary and transient over voltages, internal and external over voltages
   2. Temporary Over Voltage ; Unsymmetrical faults in the system, High capacitance of long EHV lines, Ferro-resonance, Load rejection, effective grounding, shunt compensations
   3. Switching over voltages; switching surge ratio, Energizing an unloaded transmission line, De-energizing the   transmission line, Interruption of capacitive current by circuit breaker, Current chopping by Circuit breaker, Ferro Resonance, countermeasure to reduce switching over voltages
   4. Lightning over voltages; lightning phenomena, direct and indirect lightning strokes, effect of ground wire and tower footing resistance in lightning over voltages
   5. Protection principle against lightning, lightning and surge arrestors, earth wire, grounding mast

1. **Insulation coordination: [4 hours]**
   1. Basic Insulation level and basic switching level
   2. Insulation coordination to different equipments; transformers, bus structures, bushings, transmission lines;
   3. Insulation protection level for temporary, switching and lightning over voltages
   4. surge protection: lighting and switching surge characteristics, horn gaps, grading rings, lighting arrestors

1. **High stress electric fields [8 hour]**
   1. review of electromagnetic field theory : electrostatic potential difference, potential gradient, conducting and dielectric materials in electric fields, polarization, leakage conductance of dielectrics
   2. electromagnetic fields near transmission lines; electromagnetic induction in neighboring facilities such as communication circuits, pipelines or railway tracks
   3. evaluation of electric field distributions, manual and computer flux mapping and field calculations
   4. corona and radio interference

1. **Dielectric breakdowns [8 hours]**
   1. electrical breakdown in gases: ionization and decay processes, high field cathodic emission, secondary ionization and breakdown, quenching, partial breakdown, the corona effect, polarity effects, surge effects
   2. electrical breakdown in insulating liquids: chemical breakdown of liquids, presence of impurities, polar molecules and dielectric heating in ac field
   3. electrical breakdown in solid materials: surface tracking and carbonization, air voids in solid insulating materials, effects of electrical stress concentration, polarization, energy losses and dielectric heating in ac fields

1. **Introduction to high voltage testing: [4 hours]**
   1. breakdown testing using high voltage ac and dc voltages and impulse voltages,
   2. measurement of high AC, DC and Impulse voltages, standardization of testing procedures
   3. non-destructive testing of insulations: leakage current, dielectric loss evaluation, partial discharge radio frequency sensing, impurity monitoring of liquid and gaseous insulating materials, insulations testing as routine maintenance procedures

**References:**

1. High voltage engineering, KamaRaju & Naidu
2. Extra High voltage AC  Transmission, Rakosh Das Begmudre
3. Power System Analysis by W.D. Stevension, Tata McGraw Hill Publications
4. Power System Stability and Control by P. Kundur

**Evaluation Scheme:**

|  |  |  |
| --- | --- | --- |
| **Chapter** | **Hours** | **Marks Distribution\*** |
| 1 | 6 | 8 |
| 2 | 6 | 8 |
| 3 | 8 | 16 |
| 4 | 4 | 8 |
| 5 | 8 | 16 |
| 6 | 8 | 16 |
| 7 | 4 | 8 |

**\*Note: There may be a minor deviation in marks distribution**