TRANSMISSION SYSTEM DESIGN
ENEE 414

Lecture : 3 **Year : IV**
Tutorial : 1 **Part : I**
Practical : 2

Course Objectives:
The objective of this course is to provide students with fundamental concepts of transmission system planning and design. It covers selection of transmission voltage, conductors, insulators, supporting structures, air clearances, shielding and grounding of overhead transmission lines. The course also introduces substation layout, lightning protection, SCADA, applicable standards and environmental considerations. Students will apply engineering, economic and standard-based approaches to the preliminary design and evaluation of transmission systems

1 Introduction (6 hours)

1.1 Advantages of grid systems and role of transmission in bulk power transfer and renewable energy integration
1.2 Transmission system planning and design considerations
1.3 Technical and economic comparison of AC and HVDC transmission
1.4 Major components of overhead transmission lines: conductors, insulators, towers, earth wires, grounding and foundations
1.5 Right-of-way, route selection, terrain and weather considerations, including environmental and climate-resilient design
1.6 Emerging transmission technologies: EHV/UHV, Gas-Insulated Transmission Line (GIL) and applications of FACTS devices

2 Transmission Voltage Level and Number of Circuit Selection (6 hours)

2.1 Effect of voltage level on transmitted power, losses, conductor and insulation economy
2.2 Technical aspects of AC overhead lines: power transmission capability as functions of line length, impedance and voltage level
2.3 Selection of transmission voltage for single and multiple circuits considering technical, economic and reliability requirements
2.4 Economic comparison of alternative transmission schemes and emerging EHV/UHV practices

3 Air clearance computations (6 hours)

3.1 Introduction to air clearances: importance and types of clearances; phase-to-phase, phase-to-ground, conductor-to-tower and conductor-to-ground clearances

3.2 Factors affecting air clearance: system voltage, over voltages, atmospheric conditions, conductor swing, insulator string swing, cross-arm and tower geometry

3.3 Determination of conductor-to-tower and conductor-to-ground clearances considering wind-induced conductor swing

3.4 Insulator string configurations: vertical, horizontal and V-string arrangements and their effect on tower dimensions

3.5 Earth-wire selection: factors affecting the number and arrangement of earth wires; single and double earth-wire systems

4 Overhead Line Insulator Design (8hours)

4.1 Factors affecting insulator design and selection

4.2 Insulator materials: porcelain, toughened glass and composite/polymer insulators; types and applications

4.3 String insulators, voltage distribution, string efficiency and methods of improving string efficiency

4.4 Electrical clearance and insulation coordination: temporary, switching and lightning over voltages; Basic Insulation Level (BIL)

4.5 Overvoltage control and surge protection; effect of lightning/surge arresters on insulation requirements, creepage distance and flashover

4.6 Determination of minimum number of insulator discs considering operating voltage, over voltages and mechanical requirements

5 Conductor and Support Selection (11 hours)

5.1 Electrical, mechanical, thermal and economic requirements

5.2 Conductor materials and types: AAC, AAAC and ACSR

5.3 High-Temperature Low-Sag (HTLS) and ACCC conductors; applications in transmission capacity upgrading

5.4 Electrical performance: ampacity, voltage regulation, efficiency, losses and corona; corona inception voltage and mitigation

5.5 Conductor selection, wire types and sizes; bundled conductors

5.6 Economical conductor size; Kelvin's law and its limitations for EHV transmission

5.7 Transmission-line route selection and surveying requirements

5.8 Mechanical aspects: tension, sag, temperature and wind effects, stringing chart and supports at unequal levels

5.9 Tower structural types: self-supporting lattice steel towers (suspension, tension/angle, dead-end/terminal), guyed, narrow-base and monopole structures

5.10 Tower loading criteria: vertical, transverse and longitudinal loads under normal and broken-wire conditions; tower spotting

6 Substation, Lightning Protection, Standards and Project Design (8 hours)

6.1 Substation site selection criteria and design considerations

6.2 Layout planning for Air-Insulated (AIS), Gas-Insulated (GIS) and hybrid substations; compact and modular substation trends

6.3 Lightning shielding: shielding angle and rolling sphere methods

6.4 Shield wires, shielding failure, back-flashover and surge protection coordination

6.5 Transmission-line and substation grounding; tower footing resistance and its effect on lightning performance

6.6 SCADA systems, remote monitoring and control

6.7 Applicable design standards: IEC, IEEE and NEA specifications for Nepal

6.8 Design documentation, drawing conventions, technical specifications, design checklists and cost estimation

6.9 Environmental and social considerations in transmission-line and substation design

Tutorial (15 hours)

1. Voltage level and number of circuit selection: optimum voltage considering power transfer, losses, energy cost and conductor/insulator economy.
2. Air clearance and insulator string design: clearance computation, string efficiency and selection of disc/composite insulator strings.
3. Corona inception voltage and corona loss: effect of conductor radius, spacing and atmospheric conditions; mitigation measures.
4. Conductor selection and economical conductor size: electrical, mechanical and economic requirements; application and limitations of Kelvin's law.
5. Sag, tension and stringing: sag and tension under different conditions, supports at unequal levels and stringing chart preparation.
6. Tower and lightning protection: basic tower loading, span selection, earth-wire arrangement, shielding and grounding calculations

Practical (30 hours)

A complete preliminary design of an overhead transmission line for a given transmission distance and power-transfer requirement, including selection of transmission voltage and number of circuits, conductor and insulator selection, air-clearance computation, corona and electrical performance evaluation, sag and tension calculation, tower/span selection, earth-wire and lightning-shielding arrangement, route and environmental considerations, technical specification, basic cost estimation, drawings and final performance evaluation.

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	6	8
2	6	10
3	6	8
4	8	10
5	11	14
6	8	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Glover, J. D., Sarma, M. S., & Overbye, T. J. (2017). Power system analysis and design (Latest ed.). Cengage Learning.
2. Stevenson, W. D., Jr. (1982). Elements of power system analysis (Latest ed.). McGraw-Hill.
3. Deshpande, M. V. (2001). Electrical power system design. Tata McGraw-Hill.
4. Wadhwa, C. L. (2017). Electrical power systems (Latest ed.). New Age International.
5. Kothari, D. P., & Nagrath, I. J. (2019). Power system engineering (3rd ed.). McGraw Hill Education.
6. Westinghouse Electric Corporation. (1964). Electrical transmission and distribution reference book (Latest ed.).
7. CIGRE Technical Brochures on HTLS conductors and HVDC/VSC transmission technology.
8. IEC 60826: Design criteria of overhead transmission lines.
9. IEEE Std 80: Guide for safety in AC substation grounding.