COURSE STRUCTURE & SYLLABUS OF BACHELOR OF TECHNOLOGY (B.TECH)

In

ELECTRICAL

Course Structure

Fourth Year

VII Semester

Elective – I

Paper Code	Name of the Subject
BEE5-I	EHV Transmission
BEE5-II	Power System Reliability
BEE5-III	Illumination Engineering
BEE5-IV	High Voltage Engineering

Syllabus

BEE5-1 : EXTRA HIGH VOLTAGE (EHV) TRANSMISSION

1. **HVDC POWER FLOW**
   Subscripts and symbols, Thyristor principle and control, Power conversion principle, Direct Voltage Ud1 and Ud2, Power at Rectifier-end Pd1, Power at Inverter-end Pd2, Power loss in DC system, Power in middle of HVDC line, Power at sending end, Power at receiving end, General equations, Solved Numerical examples on Pd and Ud, Summary and Questions.

2. **CONVERTER CONNECTIONS, RECTIFIER AND INVERTER WAVEFORMS**
   Rectifier Bridge Connections and Waveforms on AC and DC side, Six Pulse Bridge (Graetz Bridge), 12-Pulse Bridge, Phase Control and Delay angle, Effect of Phase control on DC Voltage, Valve Voltage, Inversion, Connections of Converter Bridge, Commutating Reactance, Angle of Overlap Extinction Angle, Significance of Delay Angle and Extinction Angle, Control of DC Voltage, Configuration of Bipolar 2T HVDC System, Valves and Converters, Summary and Questions.

3. **REACTIVE POWER COMPENSATION IN HVDC SUBSTATIONS**
   Reactive Power requirements of HVDC Converters, P.Q.S., Reactive Power Q required by converter, and HVDC Substation, Reactive power equations, Effect of delay angle and Extinction angle, Short Circuit Ratio (SCR), Impedance of AC Network, Equivalent short circuit ratio, SCR in Planning of HVDC. Transient Voltage Rise, Summary and Questions.

4. **MULTI-TERMINAL HVDC SYSTEMS**
   Two pole HVDC with earth return, substation poles in different locations, MTDC System with series connected convertors, MTDC System with parallel connected converters, Control of Parallel connected HVDBC System, Reversal of power in a terminal of HVDC System, Three TDC System with parallel tapping , Two pole reversal in 3 TDC System, HVDC Breakers in MTDC System, Applications of MTDC Systems, Worlds First Commercial 3 TDC System, World's first 5 TDC System, Configuration and Type of HVDC System, Summary and Questions.

5. **INSULATION REQUIREMENT OF EHV – AC AND HVDC EQUIPMENT AND TRANSMISSION LINES**
   Classification : Self restoring and Non-self restoring insulation, Insulation Design Aspects, Stresses on Insulation , Tests, Causes of Flashover through Air and Gases, Insulation withstand characteristics of Air Gaps, Leakage Distance or Creepage Distance of AC Insulators, Leakage Distance or Creepage Distance of DC Insulators Line Insulator Design with respect to Creepage Distance, Voltage Grading Rings (Collector Rings) to reduce pollution, Grease or Petroleum Jelly to reduce flashovers, Electrolytic Action affecting pin type DC Insulators. Effect of Wetting and contamination on leakage currents, Clearances (Insulation Distance) for AC and HVDC, Clearances in HVDC Substations, Choice of Clearance based on impulse withstand level, summary and questions.

6. **ENGINEERING ASPECTS OF EHV – AC TRANSMISSION AND TRANSMISSION PLANNING**
   Electrical, Mechanical and Thermal Design Aspects, Engineering Aspects of EHV AC Transmission system, Transmission Planning and its co-relation with Generation Planning, Distribution Planning, Why 400 kV AC was selected in India, Recent advances, Summary and Questions.

7. **ELECTROSTATIC FIELD AT GROUND LEVEL AND BIOLOGICAL EFFECTS (EHV –AC AND HVDC)**
   Basic principles and terms in Electromagnetic Field theory, Significance of Electric Field Intensity (Negative of Potential Gradient) at ground level, Electric field intensity of 3 phase AC line at ground level beneath the conductors and at the edge of Row, Charging of Objects, Vehicles and Human Body, Biological effects on Human Beings, Shock Effects of Electric Field, Contact Currents, Limiting Values of 50 Hz Contact Currents, Summary and Questions.

8. **CORONA AND CORONA LOSSES (EHV – AC AND HVDC)**
   Principle of Corona, Emperical Formulae for Ec and Ecr, Terms and Definitions, Corona of AC Overhead Lines, Factors affecting Corona, Conclusion of Research on Bad Weather Corona, Corona Losses in AC Transmission, Variation in Corona Loss during one year, factors affecting Corona Losses, Notations of terms in Derivations, Critical Surface Gradient, Peek's Law, Critical Disruptive Voltage and
   Critical Electric Stress for Visual Corona, Corona Phenomenon with HVDC, Critical HVDC Voltage and Corona, Bipolar Corona Loss, Influence of Weather on DC Corona Loss, Summary and Questions.
9. **RADIO INTERFERENCE, TV INTERFERENCE AND AUDIBLE NOISE (EHV – AC & HVDC) RADIO INTERFERENCE**
   Units of Measurement of RI, Generation of RI, propagation and Attenuation of RI, Attenuation of RI waves, Radio Interference Field Strength against Distance, RI Design Criterion for EHV AC Line, Signal to Noise Ratio (SNR), Broadcast Signal Strength, RI Lateral Attenuation with Distance, RI at Edge of Row, Minimising RI and TVI, Bundled Conductor for reducing Corona and RI, Evaluation of RI by Comparison Method & Semi Analytical Method.

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TV Interference : Comparison Formula for TVI Calculation of AC Lines RI and TVI Calculation of AC Lines RI and TVI in HVDC Overhead Lines, Elimination of DC Harmonics, RI from Bipolar HVDC Line, Comparision of RI from HVDC line and EHV AC line TVI from HVDC Line.
Audible Noise : Terms and Defintions of Acoustics, Fundamentals of Sound, Measurement of AN and weighting curves, Attenuation of Sound Pressure Level, Acceptable Level of Audible Noise, Causes of AN in substation and Transmission Line, Audible Noisein Transformers and reactors, Audible Noise in Transmission Lines, Limits of AN, Transmission Line Design based on AN, Steps in Evaluating RN, Day and night equivalent of AN, Calculation and Estimated AN of Transmission line, Sound Level of Transmission line, AN of HVDC line, Summary and Questions.

BEE5-II : POWER SYSTEM RELIABILITY

1. THE STABILITY PROBLEM
Definations and illustyrations of terms, Multimachine systems, A mechanical analogue of system stability, Bad effects of instability, Scope of this book, Historical review.

2. THE SWING EQUATION AND ITS SOLUTION
Review of the laws of mechanics; translation, Rotation, The swing equation, The inertia constant, Point-by-point solution of the swing equation, Assumptions commonly made in stability studies.

3. SOLUTION OF NETWORKS
The impedance diagram (positive-sequence*network), per-unit quantities, Representation of large synchronous machines, Transmission lines and cables, Representation of loads, representation of faults, Miscellaneous equipment, Representation of remote of the system, Check list of data required for transient-stability study, The alternating-current calculating board, Description of General Electric A-C, Network Analyzer, Procedure for using calculating board, Algebraic solution of networks: determination of terminal admittances, Algebraic solution of networks: network reduction, Repeat steps 3 and 4 until all nodes except the terminals have been eliminated***, Determination of initial operating conditions, Network reduction by use of calculating board, Combining machines, Treatment of synchronous condensers.

4. THE EQUAL-AREA CRITERION FOR STABILITY
Applicability of the equal-area criterion, One machine swinging with respect to an infinite bus, The power-angle equation, Applications of the criterion, Two finite machines, Reactance network, Determination of swing curve by graphical integration.

5. FURTHER CONSIDERATION OF THE TWO-MACHINE SYSTEM
Pre-calculated swing curves, Effect of fault-clearing time on transient stability limit, Summary of methods of calculating transient stability, Certain factors affecting stability.

6. SOLUTION OF FAULTED THREE-PHASE NETWORKS
Symmetrical components, Sequence impedances, The sequence networks, Representation of short circuits by connections between the sequence networks, Fault shunts, Effect of type of fault on stability, Effect of fault impedance, Unsymmetrical open circuits and series impedances, Simultaneous faults and other double unbalances, The zero-sequence network, Representation of lines in the zero-sequence network, Representation of transformers in the sequence networks, Effect of grounding on stability, Two-phase coordinates.

7. TYPICAL STABILITY STUDIES

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Description of systems, Fault locations, Swing curves, Stability during load condition I : faults on 132-kv. System of company A, Study of proposed changes at station BB, Faults on the 44-kv, system of company A, Faults on the 44-kv. Line between stations BE and BG, Faults on 44-kv, line between stations BG and BH, Stability during load condition 2, Proposed interconnecting lines, Scope of the study, Loads, Method of determining power limits, Simplification of systems, Swing curves, part 1, Power-angle curves, part 2, Staged-fault tests.

BEE5-III : ILLUMINATION ENGINEERING

1. LIGHT, SIGHT & COLOUR

Electromagnetic radiation, Laws of radiation, Light flux, Light intensity, illuminance laws, Luminance, Surface reflectance, Structure of the eye, photopic, mesopic and scotopic vision, trichromatism, perception details, visual performance, adaptation, flicker, glare, perception of objects and spaces, photocell, lighting measurement, physics of colour, colour mixing, colour appearance, colour temperature, surface colours, colour rendering & rendition index.

2. LAMPS AND ACCESSORIES

Light production by gas discharge, fluorescence, incandescence, daylight principle of operation, light efficacy, colour, electrical characteristics, typical applications, dimming condition of GLS filament, tungsten halogen lamps, fluorescent tubes, compact fluorescent lamp (cfl), low and high pressure sodium lamps, high pressure mercury lamp, metal halide lamp.

3. LUMINARIES

Functions of luminaries, classification, Materials Used in luminaries manufacturing, reflection, refraction, diffusion, polarization and optical design, photometric measurements, application data and its use.

4. INTERIOR LIGHTING

Objectives quantity and quality of light, selection of lamps, luminaries section, placement. Design considerations for lighting of offices, conference rooms, hospitals, teaching places, house, hotels, art galleries, museums, shops, shopping centres, temples factories etc., design calculations.

5. EXTERIOR LIGHTING DESIGN

Exterior lighting objectives, choice of lamps type, luminaries, lighting of parks and gardens, pathways, outdoor work areas. Lamps and luminaries photometric data and its use in design calculation, glare consideration.

6. ROAD LIGHTING

Aims of road lighting, quantitative and qualitative lighting needs, luminance concept, road reflection characteristics, light sources, luminaries, road lighting design calculations, sliting of luminaries on straight roads, junctions, and special situations, esthetics, maintenance, lighting for residential colony road lighting, tunnel lighting design requirements and criteria. High mast lighting for roads.

7. UTILITY AREA LIGHTING

Objectives of utility area lighting, lighting for marshalling yards, outdoor working and storage areas, container terminals, airport aprons, docks and harbors etc., ask analysis and considerations for lighting parameters and design.

8. SPORTS LIGHTING

Indoor and outdoor games, lighting parameter requirements for players, TV cameras, horizontal and vertical luminance, glare limitation, level of competition, light sources, location of luminaries.

9. DECORATIVE FLOOD LIGHTING

Introduction to the principle of decorative building flood lighting, consideration for the shape and form, selection of lamps and luminaries, design criteria.

10. EMERGENCY LIGHTING

Regulations standards and its requirements, escape lighting, standby system.

11. LIGHTING CONTROLS

Types of lighting controls, strategy for selection, benefits of lighting control.

12. DISTRIBUTION OF SYSTEM AND MAINTENANCE

Electric distribution system for lighting, maintenance strategies, group replacement schedule.

13. ENERGY EFFICIENT LIGHTING DESIGN AND COMPUTER AIDED LIGHTING DESIGN

Techniques of achieving energy efficient lighting design, role of computers in lighting design, advantages and limitations of computer aided lighting design.

BEE5-IV : HIGH VOLTAGE ENGINEERING

1. ELECTROSTATIC FIELDS THEIR CONTROL AND ESTIMATION

Electric field stress, its control and estimation, analysis of Electrical field intensity in Homogenous Isotropic Single dielectric and multi dielectric systems. Introduction to Numerical methods for the estimation of electric field intensity.

2. CONDUCTION AND BREAKDOWN IN AIR AND OTHER GASEOUS DIELECTRICS IN ELECTRIC FIELDS.

Ionization processes, Townsend's current growth equation-primary and secondary processes, townsend's criterion for breakdown in electronegative gasses, Paschen's law, breakdown in non-uniform fields and corona discharges, post-breakdown phenomena and application, practical considerations in using gas for insulation purposes.

3. CONDUCTION AND BREAKDOWN IN LIQUID DIELECTRICS

Conduction and breakdown in pure liquids, conduction and breakdown in commercial liquids.

4. BREAKDOWN IN SOLID DIELECTRICS

Intrinsic, Electro – Mechanical and Thermal breakdown, Breakdown of solid dielectrics in practice, Breakdown of composite insulation, solid dielectrics used in practice, application of insulating materials in electrical power apparatus, electronic equipments.

5. GENERATION OF HIGH VOLTAGE AND CURRENTS

Generation of HV DC, HV AC and Impulse Voltage, Generation of impulse currents, Tripping and control of impulse generators.

6. MEASUREMENT OF HIGH VOLTAGE AND CURRENTS

Measurement of HV DC, HV AC and impulse voltage and currents.

7. TESTING AND EVALUATION OF DIELECTRIC MATERIALS AND POWER APPARATUS.

Non – Destructive Testing of dielectric materials, DC resistivity measurement, Dielectric and loss factor measurement, partial discharge measurement, testing of insulators, bushing, isolators, circuit breakers, cable, transformers, high voltage motors, surge diverters, radio interference measurement.

8. HIGH VOLTAGE LABORATORY – DESIGN, PLANNING AND LAYOUT

Size and dimensions of the equipment and their layout, earthing and its importance.

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