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Indus Institute of Technology & Engineering
Department of Electrical Engineering

M.Tech in Electrical Engineering (Electrical Power System)

PS510106 Overvoltage Transients in Power System

[Unit 1] Fundamental concepts of Switching transients in power system [09]

Introduction, sources of electrical transients, Transient analysis of three phase power systems, Switching transients : The short line fault, Circuit breakers, Circuit breaker recovery voltage, Modelling of the switching arc of Circuit breakers

[Unit 2] Wave Propagation on single and multi conductor system [09]

Introduction, velocity of travelling waves and characteristics impedance ,wave equation, Wave propagation on multi conductor system, wave equation, Transition points in multi-conductor system, Reflection and refraction of travelling waves, lattice diagram, Effect of dissipation on wave propagation, Effect of finite soil conductivity, Modal analysis, Ground impedance

[Unit 3] Lightning phenomena and Switching surge phenomena [09]

Mechanism of the lightning flash, Wave shapes of the lightning currents, Direct lightning stroke to transmission line tower and , Direct lightning stroke to a line, Grounding for protection against lightning, Steady state Tower-Footing resistance, Dynamic tower footing resistance, concentrated and extended grounding system,

Introduction, Current suppression or chopping, Switching surges in capacitive circuits, System performance under switching surges, mechanism of air breakdown, Critical flashover voltage of insulation under switching surges, Phase to phase switching surge

[Unit 4] Response of overhead lines to lightning strokes [09]

Direct lightning stroke to overhead lines without shielding wires, introduction, stroke to tower, Direct lightning stroke to overhead lines with shielding wires,

stroke to tower, stroke to shield wire, Lightning induced voltages on overhead lines of finite length, Surge arrestors, introduction, and type.

[Unit 5] Numerical simulation of electrical transients and Insulation Co-ordination [09]

The electromagnetic transient program, The MNA program, The Xtrans program, Insulation co-ordination, Introduction ,terminology , basic requirement, Classification of insulation for insulation coordination, Application of insulation coordination, Insulation coordination in high voltage dc system

Reference Books:

1. C.S.Indulkar & D.P.Kothari - Power System Transients: A statistical approach -Prentice Hall.
2. V. Venicov - Transient Processes in electrical power systems-Mir publishers
3. Lou Van Der Sluis - Transients in electrical power systems, John Wiley & Sons publishers

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PS510107 Power System Modelling & Analysis

Course Contents

[Unit 1] Power Flow Study & Modeling [09]

Satic Load flow Equation formation, Disturbance variables, control variables & state variables, practical constraints, types of buses, Gauss iterative method, algorithm, flow chart and programming, Gauss-Seidal without PV buses, algorithm, flowchart and programming, Gauss-Seidal with PV buses, algorithm, flowchart and programming, Newton-Raphson method without PV buses, algorithm, flowchart and programming, Newton-Raphson method with PV buses, algorithm, flowchart and programming, Fast Decoupled Load Flow method (FDLF), algorithm, flowchart and programming

[Unit 2] Synchronous Machine Concept & Modeling [15]

Physical Description, Armature & Field Structure, MMF waveforms, direct & quadrature axis, Mathematical Description of synchronous machine, review of magnetic circuit, Basic equation of synchronous machine, Parks transformation, Classification of synchronous machine modelling as per IEEE, Electrical Transient performance characteristics for Synchronous machine,3 phase short circuit at terminal of Synchronous machine, Magnetic saturation,
Improve of modelling of saturation, Equation of Motion.

[Unit 3] Modeling of Speed Governing & Excitation System [12]

Introduction, Modeling of Speed governing System, Mechanical and Electro hydraulic controlled speed governing system, General Model for speed governing system, Introduction to excitation system, Excitation System Schematic diagram with elements of excitation system, D.C. excitation systems, A.C. excitation systems, over excitation and under excitation limiters.

[Unit 4] Transmission Line & Load Modeling [12]

Introduction, Objective for AC transmission Line, Electrical Characteristics for overhead line and underground cables, Performance equation , surge impedance loading and Equivalent circuit of transmission line, transmission line parameters, Performance requirement of Power transmission line, Power transfer and stability consideration.
Basic Concept of load modeling, Static Load Modeling, Dynamic Load modeling, Synchronous

Motor Modeling, Acquisition of load model parameter, Measurement based Approach and Component based Approach, state estimation

References:

1.	P. S. Kundur		Power System Stability and Control, McGraw Hill Inc, New York.
2.	K.R.Padiyar	-	Power System Dynamics - Stability and Control, BS Publishers, Hyderabad
4.	Power System Analysis	-	John J. Grainger and William D. Stevenson, Tata McGraw-Hill
5.	Power System Analysis	-	T. K. Nagsarkar and M. S. Sukhija, Oxford University Press
6.	I. J. Nagrath and D. P. Kothari	-	Modern Power Systems Analysis, Tata McGraw Hill.

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PS510108 Modern Control System

[Unit 1] **[16]**

Mathematical Background – Matrices: Definition of Matrices; Matrix Algebra; Matrix Multiplication and Inversion; Rank of a Matrix; Differentiation and Integration of Matrices. State Space Analysis of Control Systems: State Variables; State-Space Representation of Electrical, Mechanical and Electromechanical Systems; State Space Representation of nth Order Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between State Equations and Transfer Functions; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form; Controllability Canonical Form; Observabilty Canonical Form; Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition; State Diagram; Solution of the Time Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems.

[Unit 2] **[11]**

Controllability and Observability: Concept of Controllability and Observability; Kalman's Theorems on Controllability and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function.

[Unit 3] **[10]**

Liapunov Stability Analysis : Stability of Equilibrium State in the Sense of Liapunov; Graphical Representation of Stability; Asymptotic Stability and Instability; Sign-Definiteness of Scalar Function; Second Method of Liapunov; Stability Analysis of Linear Systems; Krasovski's Theorem; Liapunov Function Based on Variable Gradient Method.

[Unit 4] **[08]**

State Feedback Control Design:
Design of Robust Control Systems; State Feedback Control-Pole Placement Design, State Feedback with Integral Control. Observer Design: Design of Observer

References:

1. Modern Control Engineering, Fourth Edition, Prentice Hall, 2001- Katsuhiko Ogata
2. Automatic Control Systems, High Education Press, 2003- B. C. Kuo
3. Control Systems Engineering, Fifth Edition, New Age International Publishers, 2007- L. J. Nagrath & M. Gopal
4. Modern Control Systems, Sixth Edition, Addison-Wesley, 1993- Rich

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PS510109 Advanced Power System Operation & Control

Course Contents

[Unit 1] Power System Security [09]

Introduction of power system security, Concept of system security, long term & operational planning, security analysis, security enhancement, transient security analysis, sensitivity factor, contingency analysis.

[Unit 2] Economic Load Dispatch [09]

Introduction – input-output characteristics, cost curves, heat rate curve, incremental fuel rate curve, different constraints, Economic allocation of generation without transmission losses, algorithm and flowchart, programming, Transmission loss formula in terms of loss coefficients Economic allocation of generation with transmission losses, algorithm and flowchart, programming.

[Unit 3] Optimal Power Flow and Unit Commitment [09]

Optimal real and reactive power dispatch without inequality constraints, Optimal real and reactive power dispatch with inequality constraints, Introduction to UC, Comparison with Economic Load dispatch, Constraint in UC, Cost function formulation, Unit commitment solution by enumeration scheme, priority list method and Dynamic programing, Optimal Unit commitment with security Constraint

[Unit 4] Optimal Frequency Control [09]

P-f and Q-V control loops, Mechanism of real and reactive power control regulators, Steady state frequency error, dynamic frequency error, droop characteristics, P-f controller strategy for isolated area, steady state and dynamic frequency response, Two area tie-line bias control strategy, Flat frequency control, selective frequency control, tie line frequency control, Design of optimal state controller using Kalman method, State space representation of two area control, Sub-optimal and decentralized controllers, Discrete-mode AGC ,Time-error and inadvertent interchange correction techniques

[Unit 5] Load Forecasting Technique [09]

Introduction, Forecasting Methodology, Estimation of average and Trend Terms, Estimation of Periodic Components, Time Series Approach, Estimation of Stochastic Components, Long Term prediction using Economic Models, Reactive Load forecast

Reference books:

1. W. D. Stevenson - Elements of Power System Analysis, McGraw Hill Book Company, New York
.
2. S. S. Vadhera - Power System Analysis and Stability, Khanna Publishers, New Delhi.

3. O. I. Elgerd - Electric Energy System Theory: An Introduction, TMH Ltd., New Delhi.

4. L. K. Kirchmayer - Economic Operation of Power System, John Wiley and Sons, Inc., New York.

5. P. S. R. Murty - Power System Operation and Control, TMH Publications, New Delhi.

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PS510110 Power Quality

[Unit 1] Power Quality & Overview [09]

Power Quality definition, PQ characterization: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation–Power acceptability curves: CBEMA, ITIC – Sources for Electric Power Quality problem in power system: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards and Guidelines.

[Unit 2] Voltage Variation [09]

Voltage Sags - Magnitude & duration-Types- Sources of sags - Estimation of Voltage sag performance: Transmission system and Utility distribution system, Effect of sag on AC Motor Drives, Single-Phase Domestic and Office Loads, Monitoring and mitigation of voltage sag. Origin of Long & Short interruption - influence on various equipments-Basic reliability indices related interruption-monitoring and mitigation of interruption.

[Unit 3] Power Quality Analysis [09]

Measurements of Voltage, Current, Power, Energy, power factor- Time domain methods and Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform. Harmonic Distortion, Voltage versus Current Distortion, Harmonics versus Transients, Harmonic Indexes, Harmonic Sources from Commercial Loads, Harmonic Sources from Industrial Loads.

[Unit 4] Power Quality Monitoring [09]

Monitoring considerations: Power line disturbance analyser, power quality measurement equipment, harmonic / spectrum analyser, flicker meters, disturbance analyser. Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components,

Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples

[Unit 5] Power Quality Enhancement [09]

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters – Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

References:

1. Math H.J.Bollen, "Understanding Power Quality Problems-Voltage sag & Interruptions", IEEE Press, 2000.
2. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
3. Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality", McGraw Hill, 2003.
4. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition).

Jos Arrillaga, Neville R. Watson, " Power System Harmonics"- John Wiley & Sons, 2003

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PS510115 Energy Management & Audit

[Unit 1] Introduction [09]

Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting- energy audit process.

[Unit 2] Energy Cost and Management [09]

Important concepts in an economic analysis – economic models – time value of money –utility rate structures – cost of electricity – loss evaluation. Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

[Unit 3] Energy management for Motors, Systems and Electrical Equipment [09]

Systems and equipment – electric motors – transformers and reactors – capacitors and synchronous machines.

[Unit 4] Metering for Energy Management [09]

Relationships between parameters – Units of measure – typical cost factors – utility meters – timing of meter disc for kilowatt measurement – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid-state meters – metering location vs. requirements – metering techniques and practical examples.

[Unit 5] Lighting System & Co-Generation [09]

Concept of lighting systems – the task and the working space – light sources – ballasts –luminaries – lighting controls – optimizing lighting energy – power factor and effect of harmonics on power quality – cost analysis techniques – lighting and energy standards. Cogeneration: forms of cogeneration – feasibility of cogeneration – electrical interconnection.

References:

1.Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific & Technical, 1990.

2.Reay D.A., “Industrial Energy Conservation”, first edition, Pergamon Press, 1977.

3.IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.