PAAVAI ENGINEERING COLLEGE, NAMAKKAL – 637 018
(AUTONOMOUS)
M.E. POWER SYSTEMS ENGINEERING
REGULATIONS 2015
CURRICULUM

SEMESTER I

Course Code	Course Title	L	T	P	C
PMA 15105	Applied Mathematics for Electrical Engineers	3	2	0	4
PPS 15101	Advanced Power System Analysis	3	2	0	4
PPS 15102	Power System Operation and Control	3	2	0	4
PPS 15103	Modern Power System Protection	3	0	0	3
PPS 15104	EHV AC Transmission Engineering	3	0	0	3
PP* 15E**	Elective – I	3	0	0	3
PPS 15105	Power Systems Simulation Laboratory - I	0	0	4	2
PPS 15106	Technical Seminar – I	0	0	2	1

SEMESTER II

Course Code	Course Title	L	T	P	C
PPS 15201	Deregulation of Power System	3	0	0	3
PPS 15202	Power System Dynamics	3	2	0	4
PPS 15203	Power System Transients and Surge Protection	3	0	0	3
PPS 15204	Artificial Intelligence Application to Power Systems	3	0	0	3
PP* 15E**	Elective – II	3	2	0	4
PP* 15E**	Elective – III	3	0	0	3
PPS 15205	Power System Simulation Laboratory – II	0	0	4	2
PPS 15206	Technical Seminar – II	0	0	2	1

LIST OF ELECTIVES

ELECTIVE I

Course Code	Course Title	L	T	P	C
PPE 15E01	Analysis of Inverters	3	0	0	3
PPS 15E01	Power System Reliability	3	0	0	3
PPS 15E02	Insulation and Testing Engineering	3	0	0	3

ELECTIVE II

Course Code	Course Title	L	T	P	C
PPS 15E03	Flexible AC Transmission Systems	3	2	0	4
PPS 15E04	Linear and Non-Linear System Theory	3	2	0	4
PPS 15E05	Industrial Power System Analysis and Design	3	2	0	4

ELECTIVE III

Course Code	Course Title	L	T	P	C
PPS 15E06	Power System Economics	3	0	0	3
PPS 15E07	Power Quality Analysis	3	0	0	3
PPS 15E08	Power System Security	3	0	0	3

SEMESTER I

PMA 15105 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS 3 2 0 4

COURSE OBJECTIVES

- To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications.

UNIT I MATRIX THEORY 9+3

The Cholesky decomposition – Generalized Eigenvectors, Canonical basis – QR factorization – Least square method – Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS 9+3

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functional's dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints – Direct methods: Ritz and Kantorovich methods.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 9+3

Random variables – Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT IV LINEAR PROGRAMMING 9+3

Formulation – Graphical solution – Simplex method – Two phase method – Transportation and Assignment Models.

UNIT V FOURIER SERIES 9+3

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals – Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series.

TOTAL (L: 45 +T: 15): 60 PERIODS

REFERENCES:

1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, (2011).
2. Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, (1997).
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes", Academic Press, (An imprint of Elsevier), (2010).
4. Taha, H.A., "Operations Research, An introduction", 10th Edition, Pearson education, New Delhi, (2010).
5. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt.Ltd., New Delhi, (2005).
6. Elsgolts, L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, (1973).
7. O'Neil, P.V., " Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, (2003).
8. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, (2007).

WEB LINKS:

1. **http://www.sosmath.com/matrix/matrix.html**
2. **http://tutorial.math.lamar.edu/Classes/CalcI/CalcI.aspx**
3. **http://nptel.ac.in/courses/122104017/28**

PPS 15101 ADVANCED POWER SYSTEMS ANALYSIS 3 2 0 4

COURSE OBJECTIVES

- To acquire the mathematical representation of power system components and solution techniques.
- To make the students to equip with the knowledge on the power flow analysis using various methods.
- To obtain the optimal power flow solutions by using Newton's method, gradient method, LP methods.
- To gain knowledge of the different types of faults and its calculation using computer method and mathematical model.
- To impart knowledge on the concept of Numerical Integration Methods to analyze power system transient stability.

UNIT 1 SOLUTION TECHNIQUES 9+6

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

UNIT 2 POWER FLOW ANALYSIS 9+6

Power flow equation in real and polar forms; Review of Newton's method for solution; Adjustment of P-V buses; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method.

UNIT 3 OPTIMAL POWER FLOW 9+6

Problem statement; Solution of Optimal Power Flow (OPF) – The gradient method, Newton's method, Linear Sensitivity Analysis; LP methods – with real power variables only – LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

UNIT 4 SHORT CIRCUIT ANALYSIS 9+6

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. Computer method for fault analysis using ZBUS and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase domain using Thevenin's equivalent and ZBUS matrix for different faults.

UNIT 5 TRANSIENT STABILITY ANALYSIS 9+6

Introduction, Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods, Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model; Factors influencing transient stability, Numerical stability and implicit Integration methods.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- develop proper mathematical models for analysis of power system components.
- understand the methodologies of power flow studies for the power system network.
- obtain the optimal solutions for power flow problems.
- perform analysis of short circuit problems prevailing in power systems.
- apply numerical integration methods to analyse power system transient stability.

REFERENCES

1. Grainger, J.D., "Power System Analysis", Tata McGraw Hill Publishing Company, 2008.
2. Kusic, C.L., "Computer Aided Power System Analysis", Tata McGraw Hill Publishing Company, 2001.
3. Pai, M. A., "Computer Techniques in Power System Analysis", TMH Publishing Company, 2003.
4. Stagg, G. W. and Elabiad, A. H., "Computer Methods in Power System Analysis", McGraw Hill, 2010.
5. Wood, A.J. and Wollenberg, B.F., "Power Generation, Operation and Control", John Wiley and Sons, 2013.
6. Singh L.P., "Advanced power system analysis and dynamics", 3rd Ed., Wiley eastern, New Delhi, 2012.

WEB LINKS

1. media.johnwiley.com.au/product_data/excerpt/59/.../0471790559-4.pdf
2. dl.lib.mrt.ac.lk/bitstream/handle/123/1748/92960_Post-text.pdf.
3. www.kandrfarms.com/.../power-system-analysis-by-grainger-and-stevens.

PPS 15102 POWER SYSTEM OPERATION AND CONTROL 3 2 0 4

COURSE OBJECTIVES

- To understand the modelling and analysis various controlling techniques for single machine and multi machine systems.
- To impart the AVR control for single-machine infinite bus system and multi machine power systems.
- To make the students to understand the optimum generation allocation and the economic dispatch for energy management concepts in power system engineering.
- To gain knowledge on the effective implementation of coordinated hydro thermal power systems.
- To achieve knowledge on finding the least-cost dispatch of available generation resources to meet the electrical load.

UNIT 1 LOAD FREQUENCY CONTROL 9+6

Introduction, Modelling of ALFC control loop, biased control, concept of multi-area control, tie line bias control, Mathematical models of various turbine-governor systems, stability analysis of single area and multi area systems, transient stability analysis of multi-machine system.

UNIT 2 AVR CONTROL 9+6

Mathematical model of AVR control loop, modeling of various excitation systems, stability analysis of AVR systems, Lag-Lead compensation, cross coupling between AVR and ALFC control loops. Concept of AVR in multi-machine system, concept of reactive power and voltage dependency, voltage stability analysis of single machine infinite bus system.

UNIT 3 OPTIMAL GENERATION DISPATCH 9+6

Input output characteristics of a power generation units, optimum generation allocation of thermal units with and without losses, derivation of transmission loss formula, Reactive power dispatch, environmental economic dispatch, optimal dispatch of hydro units.

UNIT 4 HYDRO THERMAL COORDINATION 9+6

Advantages of coordination, optimal scheduling of hydrothermal system, short term, long term and stochastic hydro-thermal scheduling, combined working of runoff river plant with steam plant, Multi-reservoir plant, Pumped storage hydro plants.

UNIT 5 UNIT COMMITMENT 9+6

Optimal Unit commitment, Solution to unit commitment by dynamic programming, effect of start-up and shut down time/cost, optimal unit commitment with security.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- model and control single and multi machine systems.
- apply AVR control in single-machine infinite bus system and multi machine systems.
- realize power systems pertaining to economic dispatch for energy management concepts.
- implement effectively the coordinated hydro thermal power systems.
- optimize the dispatch of available generation resources to meet the electrical load demand.

REFERENCES

1. Wood, A.J. and Wollenberg, B.F., "Power Generation, Operation and Control", John Wiley and Sons, 2013.
2. Kothari, D.P., Dhillon J.S. "Power system Optimisation", 2nd Ed., PHI, 2011.
3. Elgerd O.I., "Electric Energy System Theory- An Introduction", McGraw-Hill, 2012.
4. P. Kundur, "Power System Stability & Control" Tata McGraw Hill, 2007.

WEB LINKS

1. media.johnwiley.com.au/product_data/excerpt/59/.../0471790559-4.pdf
2. www.newagepublishers.com/samplechapter/001758.pdf
3. www.unge.gq/ftp/biblioteca%20digital/.../Estabilidad%20-%20kundur.pdf.

PPS 15103 MODERN POWER SYSTEM PROTECTION 3 0 0 3

COURSE OBJECTIVES

- To introduce the characteristics and functions of relays and protection schemes.
- To illustrate the concepts of transformer protection and generator protection in faulty conditions.
- To analyse the usage of relays in distance and carrier protection for single and double end fed lines.
- To familiarize the concepts of busbar protection under various fault conditions using current transformer.
- To describe the various schemes of static comparators and analysis of numerical protection.

UNIT 1 INTRODUCTION 9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction - time – current characteristics-Current setting – Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective scheme directional earth fault relay - Static over current relays.

UNIT 2 EQUIPMENT PROTECTION 9

Types of transformers – Phasor diagram for a three phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over current protection Percentage Differential Protection of Transformers - Inrush phenomenon- High resistance Ground Faults in Transformers – Inter turn faults in transformers – Incipient faults in transformers - Phenomenon of over fluxing in transformers – Transformer protection application chart .Generator protection: Electrical circuit of the generator – Various faults and abnormal operating conditions- Stator faults- Rotor faults –Abnormal operating conditions. Induction Motor protection: Electrical Faults-Abnormal Operating Conditions from Supply side.

UNIT 3 DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays- Distance protection of a three Phase line - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against allten shunt faults - Three-stepped protection of double end fed lines - Various options for a carrier – Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II- Phase Comparison Relaying.

UNIT 4 BUSBAR PROTECTION 9

Introduction – Differential protection of busbars-external and internal fault – Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation need for high impedance – Minimum internal fault that can be detected by the high impedance Bus bar differential scheme – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three Phase busbars.

UNIT 5 STATIC COMPARATOR AS A RELAY AND NUMERICAL PROTECTION 9

Amplitude Comparator- Phase Comparator- Duality between Amplitude and Phase Comparator Introduction-Synthesis of Various distance Relay using Static Comparator. Numerical Protection: Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave – Least error squared (LES) technique - numerical over Current protection – Numerical transformer differential protection-Numerical distance protection of transmission line.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- know the construction and operation of electromagnetic relays.
- choose the protective circuit based on the knowledge of faults in equipment.
- analyse the usage of relays in distance and carrier protection for single and double end fed lines.
- know the effective usage of CT in protection circuits.
- perform synthesis of numerical protection of transmission line using static comparator.

REFERENCES

1. Ravindar P. Singh, “Digital Power System Protection”, PHI, New Delhi, 2007.
2. T.S.M.Rao, “Digital / Numerical Relays”, Tata McGraw Hill, 2005.
3. Y.G.Paithankar, S.R.Bhide, “Fundamentals of Power System Protection”, Prentice – Hall India, 2004.
4. Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice-Hall of India, 2003.
5. L.P.Singh, “Digital protection, Protective Relaying from Electromechanical to Microprocessor”, John Wiley & Sons, 1995.

WEB LINKS

1. my.mmosite.com/.../fundamentals_of_power_system_protection_pdf.ht.
2. www.spendbooks.org/1jw7fr_ebooks-digital-numerical-relays.pdf
3. www.egully.com/.../SWITCHGEAR-%26-POWER-SYSTEM-PROTECTION.

PPS 15104 EHV AC TRANSMISSION ENGINEERING 3 0 0 3

COURSE OBJECTIVES

- To provide knowledge in understanding the different aspects of design and analysis of EHV A.C Transmission systems.
- To make the students understand the analysis of various transmission line parameters.
- To gain knowledge on the impact of voltage gradients in conductors.
- To calculate different types of losses caused by corona effect.
- To acquire knowledge on the effects of electrostatic field in EHV AC transmission system.

UNIT 1 TRANSMISSION ENGINEERING 9

Role of EHV AC transmission – Standard transmission voltages – Power handling capacity and line losses – cost of transmission lines and equipment – Mechanical considerations – Indian Requirement.

UNIT 2 LINE AND GROUND PARAMETERS 9

Resistance, power loss, temperature rise properties of bundled conductors, inductance and capacitance, calculation of sequence inductions and capacitance line parameters for modes of propagations, resistance and inductance of the ground return.

UNIT 3 VOLTAGE GRADIENTS 9

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle – voltage gradients on conductors in the presence of ground wires on towers.

UNIT 4 CORONA EFFECTS 9

Power losses and audible losses: I^2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference: corona pulse generation and properties - limits for radio interference fields.

UNIT 5 ELECTROSTATIC FIELD OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants- measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- appreciate the necessity of EHV AC transmission, choice of voltage for transmission line losses and power handling capability.
- analyze the statistical procedures for line designs, scientific and engineering principles in power systems.
- predict the distribution of voltage gradients on conductors.
- calculate the losses encountered due to corona effect.
- study the effects due to the electrostatic field in EHV AC transmission system.

REFERENCES

1. Rakosh Das Bagamudre, "Extra High Voltage AC Transmission Engineering", Wiley Eastern Ltd., New Delhi, 2013.
2. Allan Greenwood, "Electrical Transients in Power Systems", John Wiley and Sons New York, 2012.
3. C.L.Wadhwa, "Electrical Power Systems", New Age International (p) Ltd Publishers, 2015.
4. S.Rao "EHVAC and HVDC Transmission Engg. Practice" Khanna publishers.
5. Arrillaga.J "High Voltage Direct Current Transmission" 2nd Edition (London) peter Peregrines, IEEE, 1998.

WEB LINKS

1. www.faadooengineers.com/.../24501-Extra-HIgh-voltage-AC-Transmission
2. https://www.scribd.com/.../Electrical-Transients-in-Power-Systems
3. www.faadooengineers.com/.../9550-Power-System-book-by-C-L-Wadhwa

PPS 15105 POWER SYSTEM SIMULATION LABORATORY-I 0 0 4 2

COURSE OBJECTIVES

- To provide better knowledge on power system problems and analysis through digital simulation.

LIST OF EXPERIMENTS

1. Power flow analysis by Newton-Raphson method and Fast decoupled method.
2. Transient stability analysis of single machine-infinite bus system using classical machine model.
3. Contingency analysis: Generator shift factors and line outage distribution factors.
4. Economic dispatch using lambda-iteration method.
5. Unit commitment: Priority-list schemes and dynamic programming.
6. Analysis of switching surge using EMTP: Energisation of a long distributed- parameter line.
7. Analysis of switching surge using EMTP: Computation of transient recovery voltage.
8. Simulation and Implementation of Voltage Source Inverter.
9. Digital over current relay setting and relay coordination.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- simulate and implement the power systems analysis in power system simulation software.
- understand the basics of design aspects of EMTP, single machine-infinite bus system and Contingency analysis.
- implement the economic dispatch and unit commitment programming.

PPS 15106 TECHNICAL SEMINAR - I 0 0 2 1

COURSE OBJECTIVES

- To help students to acquire communication and presentational skills and their application in social communication.
- To strengthen their prospects of success in technical presentation.

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- communicate effectively.
- prepare quality and focused presentation.
- learn skills essential for becoming successful student researchers.

SEMESTER II

PPS 15201 DEREGULATION OF POWER SYSTEMS 3 0 0 3

COURSE OBJECTIVES

- To introduce the concepts of deregulation for restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To understand the concept of ancillary services for deregulation power system.
- To familiarize the recent development in Indian power systems.

UNIT 1 INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT 2 TRANSMISSION CONGESTION MANAGEMENT 9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

UNIT 3 LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Mathematical preliminaries: -Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality - Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT 4 ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - ancillary service –Co-optimization of energy and reserve services - International comparison - Transmission pricing – Principles – Classification – Role in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

UNIT 5 REFORMS IN INDIAN POWER SECTOR 9

Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the restructuring of power industry and market models based on contractual arrangements.
- know the fundamental concepts of congestion management.
- suggest the marginal transmission pricing network.
- formulate pricing of transmission network with the impact of ancillary services.
- demonstrate the framework of Indian power sector and its future reorganization.

REFERENCES

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility", 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Publications., 2015.
3. Sally Hunt, "Making competition work in electricity", John Willey and Sons Inc, 2002.
4. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

WEB LINKS

1. www.springer.com/cda/content/.../cda.../9781852336707-c1.pdf.
2. www.powershow.com/.../Deregulation_as_a_Power_Engineering_Course.
3. www.powerworld.com/files/tjo_sum99_market.ppt

PPS15202 POWER SYSTEM DYNAMICS 3 2 0 4

COURSE OBJECTIVES

- To know the basics of mathematical description of a synchronous machine.
- To illustrate the modelling of excitation system and speed governing systems for power generation control.
- To understand the concept of system stability analysis with and without controllers for various power system networks.
- To analyze the transient stability using various approaches.
- To learn instability analysis of power system transmission using digital simulation.

UNIT 1 SYNCHRONOUS MACHINE MODELING 9+6

Synchronous Machine - Physical Description - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances - dq0 Transformation - Per Unit Representation - Equivalent Circuits for direct and quadrature axes - Steady-state Analysis - Steady-state equivalent circuit, Computation of steady-state values Equations of Motion - Swing Equation, H-constant calculation - Representation in system studies - Synchronous Machine Representation in Stability Studies - Simplified model with amortisseurs neglected: - classical model with amortisseur windings neglected.

UNIT 2 MODELING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9+6

Excitation System Modeling - Excitation System Requirements - Types of Excitation System - Rotating Rectifier and Potential-source controlled-rectifier systems: hardware block diagram and IEEE(1992) Type ST1A block diagram. Turbine and Governing System Modeling: Functional Block Diagram of Power Generation and Control - Schematic of a hydroelectric plant - classical transfer function of a hydraulic turbine (no derivation) - special characteristic of hydraulic turbine - electrical analogue of hydraulic turbine Governor for Hydraulic Turbine - Requirement for a transient droop, Block diagram of governor with transient droop compensation - Steam turbine modeling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

UNIT 3 SMALL-SIGNAL STABILITY ANALYSIS WITH AND WITHOUT CONTROLLERS 9+6

Classification of Stability - Basic Concepts and Definitions: Rotor angle stability - Fundamental Concepts of Stability of Dynamic Systems: State-space representation - stability of dynamic system - Linearisation, Eigen properties of the state matrix – eigenvalue and stability - Single-Machine Infinitie Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example - Effect of field flux variation on system stability: analysis with numerical example -Effects Of Excitation System - analysis of effect of AVR on synchronizing and damping components using a numerical example - Multi-Machine Configuration - Equations in a common reference frame - Formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example.

UNIT 4 TRANSIENT STABILITY ANALYSIS 9+6

Introduction - Factors influencing transient stability – Review of Numerical Integration Methods - Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation - Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned - explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using simultaneous-implicit approaches.

UNIT 5 INSTABILITY ANALYSIS 9+6

Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method. Transient stability controllers. Introduction to voltage instability, analysis of voltage Instability.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the fundamental dynamic behavior of power systems.
- comprehend concepts in modeling and simulate the dynamic phenomena of power systems.
- examine the effectiveness of controllers in power system stability
- interpret results of system stability studies.
- demonstrate the theory and practice of modeling power system components.

REFERENCES

1. P. S. Kundur, "Power System Stability and Control", McGraw-Hill, 2009.
2. K.R.Padiyar, "Power System Dynamics Stability & Control", BS Publications, Hyderabad, 2007.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 2008.
4. PeterW.Sauer & M.A.Pai, "Power System Dynamics & Stability", Pearson Education, 2002.

5. IEEE Committee Report, “Dynamic Models for Steam and Hydro Turbines in Power System Studies,” IEEE Transactions, Vol.PAS-92, pp 1904-1915, November / December 1973.

WEB LINKS

1. www.unge.gq/ftp/biblioteca%20digital/.../Estabilidad%20-%20kundur.p
2. www.solvina.se/wp.../04/Power_System_Stability_Sweden_20132.pdf
3. ebitik.azerblog.com/anbar/3194.pdf

PPS 15203 POWER SYSTEM TRANSIENTS AND SURGE PROTECTION 3 0 0 3

COURSE OBJECTIVES

- To give introduction about various types of power system transients and devise a mathematical model for calculation of transients.
- To brief the students about the lightning surges and various lightning protection schemes.
- To acquire knowledge about line surges due to switching and its protection.
- To familiarize the students in transient calculation in transmission lines.
- To analyze the recent advancements in insulation co-ordination.

UNIT 1 INTRODUCTION 9

Review of various types of power system transients – Lightning surges, Switching surges: Inductive energy transient and Capacitive energy transient - effect of transients on power systems- relevance of the study and computation of power system transients – Surge voltage and surge current specifications (As per BIS).

UNIT 2 LIGHTNING SURGES 9

Lightning – overview - Lightning Surges-Electrification of thunderclouds – Simpson's theory of thunderclouds - Direct and Indirect Strokes - Stroke to conductor, midspan and tower – Conventional lightning protection schemes for transmission lines and terminal equipments – Advanced Lightning protection technique: Collection Volume method (Dynasphere).

UNIT 3 SWITCHING SURGES 9

Closing and reclosing of lines – load rejection – fault initiation – fault clearing – short line faults – Ferro Resonance – isolator switching surges – temporary over voltages – surges on an integrated systems – switching – harmonics – Protection scheme.

UNIT 4 TRANSIENT CALCULATION 9

Traveling wave concepts – Telegraphic Equation, Wave Propagation, Reflections – Bewley's Lattice diagrams for various cases – Analysis in time and frequency domain – Eigen value approach – Z-transform.

UNIT 5 INSULATION CO ORDINATION 9

Principles of insulation co-ordination – recent advancements in insulation co ordination – BIL, Design of EHV system – Insulation coordination as applied to transformer, substations – Examples.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand various types of power system transients and its effect on power system.
- evolve a mathematical model for transients calculation.
- know various protection schemes for lightning surges.
- analyse transients to find a effective means of protection.
- know the recent advancements in insulation co-ordination.

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1. Allan Greenwood, “Electrical Transients in Power Systems”, Willey Interscience, New York, 2010.
2. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 2013.
3. C.S.Indulkar, DP Kothari, “Power System Transients” – A Statistical approach, Prentice Hall 2010.
4. Subir Ray, “Electrical Power Systems – Concepts, Theory and Practice”, Prentice Hall of India, New Delhi, 2014.
5. Rakosh das Begamudre, “Extra High Voltage AC Transmission Engineering”, Wiley Eastern Ltd, New Delhi, 2007
6. Chakrabarthy.A, Soni.M.L, Gupta.P.V. and Bhatnagar.U.S., “A Text Book on Power System Engineering“ ,Dhanpat Rai & Co., New Delhi, 2005.

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PPS 15204 ARTIFICIAL INTELLIGENCE APPLICATION TO POWER SYSTEMS

3 0 0 3

COURSEOBJECTIVES

- To expose the concepts of feed forward neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To apply the ANN techniques to power system problems.
- To expose the application of FLS in power systems.
- To provide adequate knowledge about Genetic algorithm and its application.

UNIT 1 ARTIFICIAL NEURAL NETWORKS 9

Basics of ANN – Perceptron -Delta learning rule –Back Propagation Algorithm- Multilayer Feed forward network-Memory models-Bi-directional associative memory-Hopfield network

UNIT 2 FUZZY LOGIC SYSTEM 9

Crispness-Vagueness-Fuzziness-Uncertainty-Fuzzy set theory Fuzzy sets-Fuzzy set operations-fuzzy measures-fuzzy relations-fuzzy function. Structure of fuzzy logic controller- fuzzification models-data base-rule base-inference engine defuzzification module.

UNIT 3 APPLICATION OF ANN TO POWER SYSTEM 9

Application of Neural Networks to load forecasting, Contingency Analysis-VAR control, Economic Load Dispatch.

UNIT 4 APPLICATION FLS TO POWER SYSTEM 9

Decision making in Power system Control through fuzzy set theory -Use of fuzzy set models of LP in Power systems scheduling problems-Fuzzy logic based power system stabilizer.

UNIT 5 GENETIC ALGORITHM AND ITS APPLICATIONS 9

Introduction – Simple Genetic Algorithm – Reproduction, Crossover, Mutation, Advanced Operators in Genetic Search – Applications to voltage Control and Stability Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- explore the concepts of neural networks methods.
- learn the concept of fuzziness involved in various systems.
- implement ANN concepts to solve power system problems.

- obtain solutions to power system problems using FLS.
- Implement Fuzzy Logic, Genetic Algorithm and Neural Networks in Power Systems.

REFERENCES

1. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms And Applications, Pearson Education,
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.

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PPS 15205 POWER SYSTEM SIMULATION LABORATORY-II 0 0 4 2

COURSE OBJECTIVES

- To have hands on experience to analyze the effect of FACTS controllers and different wind energy conversion technologies.

LIST OF EXPERIMENTS

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model.
2. Small-signal stability analysis of multi-machine configuration with classical machine model.
3. Induction motor starting analysis.
4. Load flow analysis of two-bus system with STATCOM.
5. Transient analysis of two-bus system with STATCOM.
6. Available Transfer Capability calculation using an existing load flow program.
7. Study of variable speed wind energy conversion system- DFIG.
8. Study of variable speed wind energy conversion system- PMSG.
9. Computation of harmonic indices generated by a rectifier feeding a R-L load.
10. Co-ordination of over-current and distance relays for radial line protection.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to understand the basics and design aspects of STATCOM, PMSG, and DFIG for variable speed wind energy conversion system.

PPS 15206 TECHNICAL SEMINAR - II 0 0 2 1

COURSE OBJECTIVES

- To acquire communication and presentational skills.
- To enrich their knowledge on recent technical topics.

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- prepare quality and focused presentation and communicate effectively.

LIST OF ELECTIVES

PPE 15E01 ANALYSIS OF INVERTERS 3 0 0 3

COURSE OBJECTIVES

- To provide the electrical circuit concepts behind the different working modes of single phase inverters.
- To brief the different working modes of three phase inverters and various switching techniques.
- To make the students to gain knowledge on design and development of current source inverters.
- To analyse and comprehend the various operating modes of different configurations of power converters.
- To familiarize the concepts of various resonant inverter techniques and its application.

UNIT 1 SINGLE PHASE INVERTERS 12

Introduction to self commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters.

UNIT 2 THREE PHASE VOLTAGE SOURCE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques.

UNIT 3 CURRENT SOURCE INVERTERS 9

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters.

UNIT 4 MULTILEVEL INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters.

UNIT 5 RESONANT INVERTERS 6

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters- advancements in inverter technology for industrial applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the various circuit concepts of single phase inverters.
- analyse the working of three phase inverters with modulation techniques.
- design and develop current source inverters.
- derive the design criteria and analyse the various operating modes of different configurations of power converters.
- design inverters for various power applications.

REFERENCES

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 2011.
2. Bimal K.Bose., “Modern Power Electronics and AC Drives”, Pearson Education, 2009.
3. Ned Mohan,Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Inc,Newyork, 2009.
4. P.C. Sen, “Modern Power Electronics”, S. Chand Limited, New Delhi, 2008.
5. P.S.Bimbra, “Power Electronics”, Khanna Publishers, 2005.
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PPS 15E01 POWER SYSTEM RELIABILITY 3 0 0 3

COURSE OBJECTIVES

- To understand the reliability concepts and planning criteria.
- To analyze the reliability models and its applications.
- To obtain the reliability of power system through various approaches.
- To evaluate the reliability of single machine under various loading conditions.
- To evaluate the reliability of multi machine using various approaches.

UNIT 1 BASIC RELIABILITY CONCEPT 9

The General reliability function - The exponential distribution – Mean time to failure – series and parallel systems – Markov process – continuous Markov processes – Recursive Techniques.

UNIT 2 RELIABILITY MODELS AND ITS APPLICATION 9

Equipment Failure Mechanism-Availability of Equipment's-Oil Circuit Recloser Maintenance Issues - Distribution Pole Maintenance-Procedure for Grounding Testing-Insulator Maintenance- Customer Service outages.

UNIT 3 RELIABILITY APPROACHES 9

Loss of energy probability method – frequency and duration approach – conclusion spinning capacity evaluation – Load forecast uncertainty – de-rated capacity levels.

UNIT 4 SINGLE SYSTEM RELIABILITY EVALUATION 9

Average interruption rate method – The frequency and duration method – stormy and normal weather effects – The Markov process approach – system studies – Service quality criterion – The conditional probability approach – simple system application, Two plant single load system, Two plant – two load system – networked system approach

UNIT 5 MULTIPLE SYSTEM RELIABILITY EVALUATION 9

The probability array for two systems – The loss of load approach – Load forecast uncertainty – Reliability evaluation in more than two systems – interconnection benefits – The system modes of failure – The loss of load approach – The frequency and duration approach – spare value assessment – Multiple Bridge equivalents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- plan and design a model for reliable power system network .
- analyse the reliability models.
- obtain the reliability of power system through various approaches.
- evaluate single reliable systems under various loading conditions.
- evaluate the reliability of multi machine systems.

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1. Gonen, Turan, "Electric Power Distribution System Engineering", Crc, 2009.
2. Ali Chowdhury, Don Koval,"Power Distribution system Reliability: Practical Methods and Applications", 2009.
3. William H. Smith, P.E, "Electric Power System Reliability", Power smiths International, Inc., 2007.
4. Roy Billinton and R.N. Allan, "Reliability Evaluation of Power Systems", Pitman, London, 1990 Edition.

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PPS 15E02 INSULATION AND TESTING ENGINEERING 3 0 0 3

COURSE OBJECTIVES

- To acquire knowledge about the properties of organic and inorganic insulating materials.
- To study the breakdown mechanisms for various dielectric materials.
- To understand the various methods of generation and measurement of high voltage.
- To impart knowledge on electrical equipment testing techniques.
- To gain the knowledge on non destructive testing on electrical apparatus.

UNIT 1 INSULATING MATERIALS 9

Requirements for insulating materials - electrical properties - molecular properties of dielectrics - dependence of permittivity on temperature, pressure, humidity and voltage - permittivity of mixtures - practical importance of permittivity - behavior of dielectrics under alternating fields - complex dielectric constants - bipolar relaxation and dielectric loss dielectric strength - Natural inorganic insulating materials - synthetic inorganic insulating materials - natural organic insulating materials - synthetic organic insulating materials.

UNIT 2 BREAKDOWN MECHANISMS IN SOLID, LIQUID AND GASEOUS DIELECTRICS 9

Intrinsic breakdown of solid dielectrics – electromechanical breakdown - Streamer breakdown thermal breakdown - electrochemical breakdown - tracking and treeing. Breakdown due to internal discharges. Liquid dielectrics - capitation breakdown - suspended particle theory. Behavior of gaseous dielectrics - ionization processes - effect of electrodes on gaseous discharge - Townsend's theory - Streamer theory - breakdown in electronegative gases - Townsend's criterion for break down – breakdown in non-uniform fields - breakdown in vacuum insulation.

UNIT 3 HIGH VOLTAGES GENERATION AND MEASUREMENT 9

Generation and measurement of high direct voltage, alternating voltages, impulse voltages and impulse currents – Tripping and control of Impulse voltage Generator – Digital Storage Oscilloscope for impulse voltage and current measurements.

UNIT 4 ELECTRICAL EQUIPMENT TESTING TECHNIQUES 9

Necessity for high voltage testing - classification of testing methods - self restoration systems - standards and specifications - testing of power transformers - voltage transformers - current transformers - bushings - insulators - surge diverters - cables - circuit breakers and isolators – Artificial pollution testing on insulators – IEC and Indian standards.

UNIT 5 NON-DESTRUCTIVE TESTING 9

Loss in a Dielectric - Measurement of Resistivity - Measurement of Dielectric Constant and Loss Factor - High Voltage Schering Bridge - Measurement of Large Capacitance - Schering Bridge Method for Grounded Test Specimen - Schering Bridge for Measurement of High Loss Factor - Transformer Ratio Arm Bridge - Partial Discharges: equivalent circuit- Bridge Circuit - Recurrent Surge Generator.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- know the electrical properties of insulating materials
- acquire the knowledge on the different breakdown mechanisms of dielectrics.
- understand the various methods of generation and measurement of high voltage.
- acquire the knowledge of various methods of electrical equipments.
- know the use of electric bridges for non-destructive testing.

REFERENCES

1. SK Bhattacharya, “Electrical and Electronic Engineering Materials” 1st edition Khanna Publishers, New Delhi, 2006.
2. A.J. Dekker “Electrical Engineering Materials”, PHI, 2006.
3. Naidu,M.S. and Kamaraju,V., “High Voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2009.
4. C.L.Wadhwa., “High Voltage Engineering”, New Age International (P) Ltd, Publishers,2007.
5. Kuffel E., Zaengl W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005.
6. Ushakov V.Y., “Insulation of High Voltage Equipment”, Springer, 2004.

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PPS 15E03 FLEXIBLE AC TRANSMISSION SYSTEMS 3 2 0 4

COURSE OBJECTIVES

- To emphasis the need of FACTS controllers.
- To learn the characteristics, applications and modelling of SVC controllers.
- To understand the characteristics, applications and modelling of TCSC controllers.
- To know about the emerging trends of FACTS controller.
- To analyze the interaction of different FACTS controllers and perform control coordination.

UNIT 1 INTRODUCTION 9+6

Reactive power control in electrical power transmission lines –Uncompensated transmission line - series compensation – Basic concepts of Static Var Compensator (SVC)–Thyristor Switched Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT 2 STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9+6

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of svc for power flow and transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.

UNIT 3 THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS 9+6

Operation of the TCSC – Different modes of operation – Modelling of TCSC – Variable reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping-SSR Mitigation.

UNIT 4 VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9+6

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow –Modelling of SSSC in load flow and transient stability studies. Applications: SSR Mitigation-UPFC and IPFC

UNIT 5 CO-ORDINATION OF FACTS CONTROLLERS 9+6

Controller interactions – SVC – SVC interaction – Co-ordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the need for FACTS controllers.
- learn the characteristics, applications and modeling of SVC controllers.
- learn the characteristics, applications and modeling of TCSC controllers.
- update knowledge on the merging trends of FACTS controllers.
- analyze the interaction of different FACTS controller and perform control coordination.

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1. R.MohanMathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc., 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2000.
3. K.R.Padiyar,"FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008.
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PPS 15E04 LINEAR AND NON-LINEAR SYSTEM THEORY 3 2 0 4

COURSE OBJECTIVES

- To introduce the modeling and representing systems in state variable form.
- To acquire knowledge on solving linear and non-linear state equations.
- To illustrate and analyse the role of controllability and observability.
- To familiarize the nonlinearity of systems by describing function.
- To educate on stability analysis of systems using Lyapunov's theory and other techniques.

UNIT 1 STATE VARIABLE REPRESENTATION 9+6

Introduction-Concept of State equation for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT 2 SOLUTION OF STATE EQUATIONS 9+6

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential.

UNIT 3 FEEDBACK CONTROLLERS AND OBSERVERS 9+6

Controllability and Observability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Controllable and Observable Companion Forms-SISO and MIMO Systems-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

UNIT 4 ANALYSIS OF NON LINEAR SYSTEMS 9+6

Classification of nonlinearity-physical nonlinearities-Linearization of nonlinear systems-phase plane analysis-describing function analysis of nonlinear systems-Application of describing functions

UNIT 5 STABILTY 9+6

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- apply the mathematical fundamentals for deriving the state model.
- obtain solutions of state equations to derive the system matrix.
- analyse and design the linear and nonlinear systems.
- analyse non-linear system using describing functions.
- determine the complexity and stability of control systems.

REFERENCES

1. M.Gopal, "Modern Control System theory", New Age International Publishers, 2014.
2. Nagrath I.J., and Gopal, M., "Control Systems Engineering" New Age International Limited, 2013.
3. K. Ogatta, "Modern Control Engineering", Pearson Education Asia, 2010.

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PPS 15E05 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN 3 2 0 4

COURSE OBJECTIVES

- To brief about the various motor starting techniques and computer aided analysis.
- To study about power factor correction methods.
- To analyze the harmonic sources and design the harmonic filters.
- To understand the flicker analysis and conduct a case study.
- To know about ground grid analysis.

UNIT 1 MOTOR STARTING STUDIES 9+6

Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators Computer-Aided Analysis-Conclusions.

UNIT 2 POWER FACTOR CORRECTION STUDIES 9+6

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Over voltages-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

UNIT 3 HARMONIC ANALYSIS 9+6

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study- Summary and Conclusions.

UNIT 4 FLICKER ANALYSIS 9+6

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study- Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT 5 GROUND GRID ANALYSIS 9+6

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- know about the various motor starting techniques and computer aided analysis.
- demonstrate the power factor correction techniques.
- determine the level of harmonics and its effect.
- analysis the flickers and methods of minimizing its effects.
- perform ground grid calculations and analyze the performance of ground grids.

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1. Ramasamy Natarajan," Computer-Aided Power System Analysis", Marcel Dekker Inc., 2002.
2. J. Duncan Glover, Mulukutla S.Sarma, Thomas Overbye, "Power System Analysis and Design", 2011.
3. Patrick H Garrett," High performance Instrumentation and Automation", CRC Press, Taylor & Francis Group, 2005.
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PPS 15E06 POWER SYSTEM ECONOMICS 3 0 0 3

COURSE OBJECTIVES

- To brief about the various generation constraints and its load characteristics.
- To understand the methods of solving the economic dispatch problems.
- To analyse the basic electric energy market computational tools.
- To know the methods of plant location and equipment selection.
- To analyze the solutions of optimal power flow.

UNIT 1 INTRODUCTION 8

Introduction – Characteristics of Stream units, Hydro units, Cogeneration plants – Load curves – Load duration curves – Number and size of generator units – Cost of Electrical energy – Cost of service, Fixed charges, Interest applications, Investment, Taxes, Depreciation charges and Annual operating cost.

UNIT 2 ECONOMIC DISPATCH 9

Economic Dispatch problem – Thermal system dispatching with Network losses considered – Lambda Iteration method – Gradient Method – Newton's Method – Piecewise linear cost functions – Dynamic programming – Base point and participation factor – Transmission system effects – Power flow problem and its solution – Transmission Losses – Problems.

UNIT 3 UNIT COMMITMENT 8

Introduction – Constraints in unit commitment – Reserves – Unit commitment solution methods – Priority List method, Dynamic programming solution, FDP method, Lagrange Relaxation solution, Linear programming – Load Forecasting.

UNIT 4 POWER ECONOMICS 8

Selection of plant: Plant capacity, Capacity Probability analysis, Plant location, equipment selection, Equipment cost – Station performance and operation characteristics – Specific economic energy problems: Steam plant, Hydraulic plant Interconnections – Energy rates.

UNIT 5 OPTIMAL POWER FLOW AND SECURITY 12

Introduction – Solution of optimal power flow: Gradient method, Newton's method, Linear Sensitivity analysis, Linear programming methods (with real power variables & AC power flow variables) – Security constrained optimal power flow – Correction of generator dispatch by sensitivity method – Compensation factor – Voltage security assessment – Transient security assessment – Methods and Calculations – Comparisons. **TOTAL: 45 PERIODS**

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the basic economical factors related to power system.
- solve the economic dispatch problems using Newton's method and Lambda Iteration method.
- gain knowledge about unit commitment solution methods.
- make a choice on the plant location and optimal equipment selection.
- provide optimal power flow using Gradient method, Newton's method.

REFERENCES

1. Allen J.Wood, Bruce F. Wollenberg, " Power Generation, Operation and Control", John Wiley & Sons, 2012
2. Bernhardt, Skrotzki.G.A., William A. Vopat, "Power Station Engineering and Economy" Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.
3. Wadwa.C.L, "Generation, Distribution and Utilization of Electrical Energy", (Revised Edition), New Age International, New Delhi, 2006.
4. George L.Kusic,"Computer Aided Power System Analysis", Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
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PPS 15E07 POWER QUALITY ANALYSIS 3 0 0 3

COURSE OBJECTIVES

- To understand the power quality issues.
- To learn about the concept of power quality monitoring.
- To familiarize the concept of short interruptions & long interruptions .
- To analyse the various power quality issue and mitigation.
- To understand the active compensation techniques used for power factor correction.

UNIT 1 INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Nonlinear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT 2 POWER QUALITY MONITORING 9

Introduction – Power quality monitoring : Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring – Power factor improvement – Brief introduction to power quality measurement equipments and power conditioning equipments – Planning, Conducting and Analyzing power quality survey – Active Filters for Harmonic Reduction.

UNIT 3 SHORT INTERRUPTIONS & LONG INTERRUPTIONS 9

Introduction – Origin of short interruptions : Voltage magnitude events due to re-closing, Voltage during the interruption – Monitoring of short interruptions –Influence on induction motors, Synchronous motors, Adjustable speed drives, Electronic equipments – Single phase tripping : Voltage during fault and post fault period, Current during fault period. Definition – Failure, Outage, Interruption – Origin of interruptions – Causes of long interruptions – Principles of regulating the voltage – Voltage regulating devices, Applications: Utility side, End-User side.

UNIT 4 ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

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 – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT 5 LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the various power quality issues.
- know the various methods of monitoring the power quality issues.
- distinguish short and long interruptions.
- analyse the various power quality issue and mitigation.
- demonstrate the conventional compensation techniques used for power factor correction.

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5. Handbook of Power Quality, editor: Angelo Baggini, John Wiley & Sons, 2008.

WEB LINKS

1. www.materialdownload.in/article/Power-Quality-Enhancement-Using-Custom-Power-Devices
2. read.pudn.com/downloads156/.../Power%20System%20Harmonics.pdf
3. accessengineeringlibrary.com/.../electrical-power-systems-quality-third-edition.

PPS 15E08 POWER SYSTEM SECURITY 3 0 0 3

COURSE OBJECTIVES

- To impart knowledge on various power system security techniques.
- To know the various power system state estimation methods.
- To learn the security assessment in the different networks.
- To acquire knowledge on the various power system security enhancement methods.
- To update knowledge on the recent power system security techniques.

UNIT 1 INTRODUCTION 9

Factors affecting power system security, decomposition and multilevel approach, state estimation, system monitoring, security assessment and security enhancement.

UNIT 2 POWER SYSTEM STATE ESTIMATION 9

Maximum likelihood weighted least-square estimation, state estimation, detection and identification of bad measurements, estimation of quantities not being measure, network observability and pseudo measurements.

UNIT 3 SECURITY NETWORK 9

Detection of network problems, network equivalent for external system, network sensitivity methods, calculation of network sensitivity factors, fast contingency algorithms, contingency ranking, dynamic security indices.

UNIT 4 SECURITY ENHANCEMENT 9

Correcting the generator dispatch by sensitivity methods, compensated factors, security constrained optimization, preventive, emergency and restorative control through NLP and LP methods.

UNIT 5 RECENT TECHNIQUES 9

Voltage security assessment - Transient Security assessment – methods - Comparison.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student will be able to

- understand the fundamentals of security system.
- know various techniques for power system security.
- estimate and design the security assessment network.
- understand the security enhancement methods.
- update knowledge on the recent power system security techniques.

REFERENCES

1. Wood, Allen J./ Wollenberg, Bruce F./ Sheble, Gerald “Power Generation, Operation, and Control” , published by John Wiley and Sons Inc., 2013.
2. Wood, A.J. and Woolenberg, John Wiley and sons, “Power generation operation for security”, 2013.
3. Abdullah Khan, M, “Real time control of power system for security”, vol.2, Proceedings of summer school, College of Engineering, Madras.
4. Handsching.E, “Real time control of Electric Power Systems”, Elsevier publishing Co., Amsterdam.
5. George Anders, Alfredo Vaccaro, “Innovations in Power Systems Reliability”, springer publishing co.

WEB LINKS

1. cusp.umn.edu/Napa.../Wollenberg%20NAPA%20Feb%202013.pdf
2. www.iaeng.org/publication/.../WCECS2012_pp1025-1031.pdf
3. www.mit.edu/~mitter/publications/C11_hierarchical_system_EPS.pdf