EE-601 Computer Aided Power System Analysis

Network Modelling and Power Flow:

System graph, loop, cutest and incidence matrices, y-bus formation, sparsity and optimal ordering , power flow analysis, Newton Raphson method, decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow, sequential solution technique.

Fault Studies:

Analysis of three phase symmetrical and unsymmetrical faults in phase and sequence domain, phase shift in sequence quantities due to transformer, open circuit faults.

Stability Studies:

Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method.

Power System Security:

Factors affecting security, State transition diagram, contingency analysis using network sensitivity method and AC power flow method, introduction to state estimation.

Text/Reference:

1. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
2. Hadi Saadat, Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.
3. George L. Kusic, Computer Aided Power System Analysis. Prentice Hall of India (P) Ltd., New Delhi, 1989.
4. J. Arrilaga, C. P. Arnold, B. J. Harker, Computer Modelling of Electric Power System, John Wiley & Sons.K. Mahailnaos, D. P. Kothari, S. I. Ahson, Computer Aided Power System Analysis & Control, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988.
5. G. T. Heydt, Computer Analysis Methods for Power Systems, Macmillan Publishing Company, New York.
6. L. P. Singh, Advanced Power System Analysis and Dynamics, New Age, International Publishers, New Delhi.

EE-602 Electric Power Quality

Introduction:

Introduction-power quality-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, EMC standards and recommended practices.

Harmonic Device Modeling:

Harmonics-individual and total harmonic distortion-RMS value of a harmonic waveform-triplex harmonic-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices-saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

Modeling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives.

Harmonic Mitigation:

Power factor improvement-Passive Compensation. Passive filtering. Harmonic resonance. Impedance Scan Analysis-Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single static var compensators-SVC and STATCOM.

Voltage Restoration:

Active Harmonic Filtering-Shunt Injection Filter for single phase, three-phase three wire and three-phase four-wire system. Dynamic Voltage Restorers for sag, swell and flicker problems.

Grounding:

Grounding and wiring –introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.

Text Books/References:

1. Electric Power Quality by G. T. Heydt, Stars in a Circle Publishers,1994.
2. Understanding Power Quality Problems by Math H. Bollen.
3. J. Arrillaga, Power System Quality Assessment., John Wiley, 2000.
4. J. Arrillaga, B. C. Smith, N. R. Watson & A. R. Wood, Power System Harmonic Analysis, John Wiley, 1997.
5. 'Selected Topics in Power Quality and Custom Power', Course book for STTP, 2004, Ashok S.
6. Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, Electrical Power System Quality, McGraw Hills, 2002.

EE-603 Advanced Relaying and Protection

Review of: Characteristics & operating equations of basic electromagnetic relays, comparison of transistor operation with electromechanical relays. Introduction to static relays & their basic construction.

Comparators:- Introduction, mixing transformers, Amplitude comparators, Rectified bridge & direct comparators, phase comparators, direct, coincidence & phase splitting type comparators. Duality between phase & amplitude comparators.

Various Static Relays:-

Directional relays: - Integrating phase comparison type, instantaneous coincidence type, rectifier phase comparator type, amplitude comparator, directional units.

Over current relays: - Introduction, instantaneous over current relay, time - over current relay, definite time over current relay.

Differential Relays:- Introduction, types of differential relays, analysis of electromagnetic & static differential relays, differential relay equations for e.m. type & static type relays, voltage & current comparison, harmonic restraint, percentage differential relays for transformer protection.

Distance Relays: - Characteristics, elements of 3-zone directional & MHO relay protection. Special characteristics i.e. swiveling characteristic, conic section & Quadrilateral characteristic.

Microprocessor based Relay**:-** Implementation of over current, impedance, reactance, directional & Mho relays using assembly level programming.

Review of arc formation, interruption of currents in circuit breakers, operation of SF6, vacuum type and H.V.D.C. circuit breakers, different ratings of circuit breakers & testing methods of circuit breakers.

References

1 Power System protection - static Relays by "T.S.M.Rao" Tata Mcgraw Hill Publishing Co.
2 Power System protection & switchgear by "B Ravindernath &M Chander" Wiley Eastern Limited.
3 Protective relays theory & practice Vol-II-" A.R.Van & C. Warrington" Chapman & Hall.
4 Fundamental of microprocessors & microcomputers by "B.Ram" Dhanpat Rai & Sons.
5 Power System stability Vol.-II by E.W.Kimbark" John Wiley & Sons.

EE – 604 FACTS Devices and Control

Active and reactive power flow in transmission systems, mechanism of power flow control, voltage and reactive power control; basic FACTS controllers: shunt, series, shunt-series combined; SVC, STATCOM, TCSC, TSC, PAR, SSSC, UPFC; system operation performance improvement through FACTS controllers: power oscillation, first swing stability and SSR. HVDC-v/s FACTS.

Text Books/References:

"Understanding FACTS Concepts and Technology of Flexible AC Transmission System", N.G. Hingorani and L. Ayugyi

EE-606 AI Techniques and Applications

Artificial Intelligence: Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic.

Fuzzy Logic: Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

Artificial Neural Network: Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

Evolutionary Techniques: Introduction and concepts of genetic algorithms and evolutionary programming

Hybrid Systems: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems

Some Practical applications

Text Books/References:

1. NP Padhy , Artificial Intelligence and Intelligent Systems, Oxford University Press
2. Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications", PHI New Delhi.
3. Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc.
4. Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Addition Wesley Co., New York.
5. Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India.

EE-607 Power System Operation and Control

1. Economic dispatch without line losses, economic dispatch with line losses, lambda iteration method, gradient method, Newton's method, base point and participation factors.

2. Transmission losses, co-ordination equations, incremental losses, penalty factors, B matrix loss formula (without derivation), methods of calculating penalty factors.

3. Unit commitment, constraints in unit commitment, priority list method, Dynamic programming method and Lagrange relaxation methods.

4. Generation with limited energy supply, take or pay fuel supply contract, composite generation production cost function, gradient search techniques.

5. Hydrothermal co-ordination, scheduling energy, short term hydrothermal scheduling, lambda-gamma iteration method, gradient method, cascaded hydro plants, pumped storage hydro scheduling.

6. Optimal power flow formulation, gradient and Newton method, linear programming methods.

7. Automatic voltage regulator, load frequency control, single area system, multi-area system, tie line control.

Reference

1. Power generation operation and control A.J wood, B.F Wollenberg.
2. Electrical Energy system theory, O.I. Elgerd.

EE-608 Power System Restructuring and Deregulation

1. Introduction: Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.
2. Power System Restructuring: An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.
3. Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model.
4. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services.
5. Transmission Pricing: Marginal pricing of Electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract Path method, Boundary flow method, MW-mile method, MVA-mile method, Comparison of different methods.
6. Congestion Management: Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC),
7. Different Experiences in deregulation: England and Wales, Norway, China, California, New Zealand and Indian power system.

References:

1. "Power System Restructuring and Deregulation" edited by Loi Lei Lai, John Wiley & Sons Ltd.
2. "Understanding Electric Utilities and Deregulation", Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York.

EE-609 HVDC Transmission

General:- Types of DC systems, comparison of AC and DC transmission, economic factors, review of converter circuits, multibridge converters.

Converter Control:- Grid control, Basic means of control, power reversal, limitations of manual control, constant current vs constant voltage, desired features of control, actual control characteristics, constant minimum ignition angle control, constant current control, constant extinction angle control, stability of control, tap changer control, power control and current limits, multiterminal lines, measuring devices.

Protection of HVDC systems:- DC reactors, voltage oscillations & valve dampers, current oscillations and anode dampers, DC line oscillations & line dampers, fault clearing and reenergization of the line, circuit breakers, over voltage protection.

Harmonics and Filters:- Harmonics on ac side and dc side of converter, characteristics and uncharacteristic harmonics, troubles caused by harmonics, harmonic filters.

Power Flow in AC/DC systems:- General, modelling of DC links, DC load flow solution, per unit systems for DC quantities, solution methodology for AC-DC power flow.

Reference

1. Direct current transmission. E.W.Kimbark.
2. HVDC power transmission, K.P.Padiar.
3. High voltage direct current Transmission by J.Arrillage.