Common Syllabus for M. Tech. EE in Power Systems

West Bengal University of Technology

1st semester

Theory

Sl. No	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	EMM-101	Advanced Engineering Mathematics	3	1	0	4	4
2.	PSM-101	Advanced Power System Analysis	3	1	0	4	4
3.	PSM-102	High Voltage Transmission System	4	0	0	4	4
4.	PSM-103	Elective – I	4	0	0	4	4
5.	PSM-104	Elective - II	4	0	0	4	4

Practical/ Sessional

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	PSM-191	Laboratory I	0	0	3	3	2
2.	PSM-192	Laboratory II	0	0	3	3	2
3.	PSM-193	Seminar I	0	0	3	3	2
		Total of Practical/ Sessional				9	6
Total of Semester			18	2	9	29	26

2nd Semester

Theory

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	PSM-201	Power System Operation and Control	3	1	0	4	4
2.	PSM-202	Power System Instrumentation	3	1	0	4	4
4.	PSM-203	Advanced Power System Protection	4	0	0	4	4
4.	PSM-204	Elective – III	4	0	0	4	4
5.	PSM-205	Elective - IV	4	0	0	4	4

Practical/ Sessional

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	PSM-291	Laboratory III	0	0	3	3	2
2.	PSM-292	Laboratory IV	0	0	3	3	2
3.	PSM-293	Seminar II	0	0	3	3	2
Total of Practical/ Sessional						9	6
Total of Semester			17	3	9	29	26

3rd Semester

Theory

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	EMM-301	Introduction to Management	4	0	0	4	4
2.	PSM-301	Elective V	3	1	0	4	4

Practical/ Sessional

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	PSM-391	Pre-submission Defense of Dissertation	0	0	0	0	4
2.	PSM-392	Dissertation (Part I)	0	0	0	20	10
		Total of Sessional				20	14
Total of Semester			17	3	9	28	22

4th Semester

Sessional

Sl. No.	Code	Paper	Contact periods per week			Total Contact hours	Credit
			L	T	P		
1.	PSM-491	Dissertation (Completion)	0	0	0	24	14
2.	PSM-492	Post submission defense of Dissertation	0	0	0	0	8
3.	PSM-294	Comprehensive Viva-Voce	0	0	0	0	4
Total of Semester						24	26

Total Credits: 26 + 26 + 22 + 26 = 100

Elective I

i) Power System Planning and Reliability - PSM 103 (a)
ii) Power System Apparatus - PSM 103 (b)
iii) Power Quality - PSM 103 (c)

Elective II

i) Optimization Techniques - PSM 104 (a)
ii) Soft Computing Technique - PSM 104 (b)
iii) Digital Signal Processing - PSM 104 (c)
iv) Object Oriented Programming - PSM 104 (d)

Elective III

i) Power System Transient – PSM 204 (a)
ii) Flexible A.C. Transmission System - PSM 204 (b)
iii) Advanced Electrical Drives - PSM 204 (c)

Elective IV

i) Advanced Control System- PSM 205 (a)
ii) Modeling and Simulation of dynamic systems - PSM 205 (b)
iii) Advanced Microprocessor and Microcontroller – PSM 205 (c)

Elective V

i) Non-conventional Energy - PSM 301 (a)
ii) **Power System Harmonics - PSM 301 (b)**
iii) **Energy Management and Audit – PSM 301 (c)**

Advanced Engineering Mathematics

EMM 101

Contact: 3L+1T
Credit: 4

Unit I: Complex Variables
Review of complex variables, Conformal mapping & transformations, Function of complex variables, Pole and singularity, Integration with respect to complex argument, Residues and basic theorems on residues.

Unit II: Numerical Analysis
Introduction, Interpolation formulae, Difference equation, Roots of equations, Solution of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems.

Unit III: Optimization Technique
Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.

Unit IV: Linear Algebra
Vector space, Linear dependence of vectors, basis, linear transformations, inner product space, rank and inverse of a matrix, solution of algebraic equations, consistency conditions, Eigen values and eigen vectors, Hermitian and Skew Hermitian matrices.

Books:
1. John B. Conway, Functions of one complex variable, Springer International.
2. James Ward Brown & Ruel V. Churchill, Complex variable and application, Mc Graw Hill International edition .
3. John H. Mathews, Numerical Methods for Mathematics , science and Engineering, PHI
4. D.C. Sanyal and K. Das, A text Book of Numeriacl analysis, U.N. Dhar & Sons Pvt. Ltd.
5. S.S.Rao,, Optimisation theory and application, Wiely Eastern limited Hoffman & Kunze. R, Linear Algebra, PHI Control
6. Sen, M.K and Malik, D.F.-Fundamental of Abstract Algebra, Mc Graw Hill.
7. Khanna, V.K. and Ghamdri, S.K.- Course of Abstract Algebra, Vikash Pub.
8. Halmos, T.R. Naïve set theory,Van Nostrand.
9. Scarborough, J.B.- Numerical Mathematical Analysis, Oxford University Press
10. Cone, S.D. Elementary Numerical Statistics , New Central Book Agency
11. Mukhopadhyay, P. Mathematical Statistics, New Central Book Agency.
12. Kapoor, V.K and Gupta, S.C.-Fundamental of Mathematical Statistics, Suttan Chand & sons.
13. Uspensky, J.V.- Introduction to Mathematical Probability Tata Mc Graw Hill.
14. Dreyfus, S.E.- The Art and Theory of Dynamic Programming- Theory and Applications, Academic Press.
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Advanced Power System Analysis

PSM-101

Contact: 3L+1T
Credit: 4

Unit I

Network matrix: Physical interpretation of bus admittance and impedance matrices, introduction to admittance matrix formulation, formation of admittance matrix due to inclusion of regulating transformer, development of admittance matrix using singular transformation, modification of admittance matrix for branch addition/ deletion. 8

Unit II

Complex power flow: Analytical formulation of complex power flow solution, Gauss-Seidal method of power flow, Newton Raphson method of power flow, algorithm for solving power flow problem using N-R method in rectangular form, algorithm for solving power flow problem using N-R method in polar form, fast decoupled load flow method. 12

Unit III

Power System Stability: Definitions, classification of stability-rotor angle and voltage stability, synchronous machine representation for stability study. 2

Transient stability: Assumptions for transient stability, derivation of swing equation, swing equation for synchronous machine connected to infinite bus, swing equation for a two machine system, solution of swing equation by Euler and Runge Kutta method, equal area criterion, critical clearing angle, application of critical clearing angle to transient stability of synchronous machine. Methods of improving transient stability: reducing fault clearance time, automatic reclosing, single phase reclosing, electric braking, voltage regulators, fast governor action, high speed excitation system. 12

Voltage stability: Definition and classification of voltage stability, mechanism of voltage collapse, analytical concept of voltage stability for a two bus system, expression for critical receiving end voltage and critical power angle at voltage stability limit for a two bus power system, PV and QV curves, L index for the assessment of voltage stability. 6

Books

1. A. Chakrabarti,M.L. Soni, P. V. Gupta, U. S. Bhatnagar "A text book on Power System Engineering", Dhanpat Rai and Co.

2. Power system Analysis by Hadi Saadat: Tata McGraw-Hill Publishing Company Limited.
3. Power system Analysis by Charles A. Gross: John Wiley & Sons.
4. Power system Analysis by John J. Grainger & William D. Stevenson, JR: Tata McGraw-Hill Edition.

High Voltage Transmission System

PSM-102

Contact: 4L
Credit: 4

Unit 1: High voltage transmission line trends and preliminary aspects of standard transmission voltages. Comparison between HVAC and HVDC transmission, planning for HVDC transmission, links, properties of HVDC thyristor valves, components of HVDC transmission system. 4

Unit 2: HVDC converters: 6 pulse converter circuits and working principle, converter bridge characteristics, working principle and characteristics of a twelve pulse converter with two & three valve conduction mode, three valve conduction mode and three and four valve conduction mode. 10

Unit 3: Calculation of line resistance and inductances: resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductors lines and multi-conductor lines, Maxwell's coefficient matrix. 8

Unit 4: Line capacitance calculation: capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficient for bundled conductor lines, sequence inductance and capacitances. 6

Unit 5: Corona: Corona in EHV lines- corona loss formulate- Audio noise due to corona, its generation, characteristics and limits measurement of audio noise. 4

Unit 6:. Introduction of Electric Field calculation, Uniqueness theorem, Field calculation by finite difference method with equal and unequal nodal distance in 2-D and 3D system. 8

Books: 1. Rakosh Das Begamudre, 'Extra high voltage ac transmission engineering' New Age International Publisher.

2. Padiyar K. R. 'HVDC transmission systems' Wiley.

3. Arrilaga, J. 'High voltage direct current transmission' Peter Pereginver Ltd, London

Power System Planning and Reliability
PSM 103(a)

Contact: 4L
Credit: 4

Load Forecasting: Load Forecasting Categories-Long term, Medium term, short term, very short term Applications of Load Forecasting, Factors Affecting Load Patterns Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning.
Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, STLF Using MATLAB'S ANN Toolbox, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis

Power System Reliability: Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

Basic Tools and Techniques- random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

Reliability of Generation Systems- capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion.

Reliability Assessment for Elements of Transmission and Transformation Systems- reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines,.

References:
1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, Shahidehpour M, Yamin H, Li z, John Wlley & sons
2. Reliability evaluation of power systems, Billinton R, Allan R (1996) Plenum Press New York
3. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag

Power System Apparatus

PSM 103(b)

Contact: 4L
Credit: 4

Circuit Breaker: Introduction, Operating Principle, Detail study on VCB and SF6 Circuit breaker, Ratings, Selection. Surge Arrester & Surge Absorber. Insulation Co-ordination, BIL. 6

FACTS: Concepts and general system consideration: Opportunities for FACTS. Basic types of FACTS controllers. Brief description and definition of FACTS controllers. Shunt connected controllers. Series Connected controllers. Combined Shunt and Series connected controllers. 8

Static Shunt Compensators: Objectives of Shunt Compensations. Midpoints voltage regulation for line segmentation. Improvements of transient stability, Methods of controllable VAR generation. Variable impedance type static VAR generation, TCR and TSR, FC-TCR (Fixed Capacitor, Thyristor Controlled Reactor), Hybrid VAR Generators. Static VAR Compensator (SVC & STATCOM). Transfer Function and Dynamic Performance. Power Oscillation, Damping. Transient Stability. 12

Static Series Compensators: GCSC, TSSC, TCSC and SSSC: Basic Operating Control Schemes for GCSC, TSSC and TCSC. 6

Static Voltage and Phase Angle Regulators: TCVR and TCPAR. 4

Unified power flow controllers

Reference:
1. Understanding FACTS by Narain G. Hingorani & Laszlo Gyugyi: IEEE Press.
2. Power System Switchgear & Protection by Sunil S. Rao.

Power Quality

PSM 103 (c)

Contact: 4L
Credit: 4

Electric power quality phenomena: - Impacts of power quality problems on end users, Power quality standards, power quality monitoring.

Power quality disturbances:- transients, short duration voltage variations ,long duration voltage variations, voltage imbalance, wave-form distortions, voltage fluctuations, power frequency variations, power acceptability curves.

Power quality problems: poor load power factor, loads containing harmonics, notching in load voltage, dc offset in loads, unbalanced loads, disturbances in supply voltage.

Transients: Origin and classification- capacitor switching transient-lighting-load switching-impact on users-protection-mitigation.

Harmonics: harmonic distortion standards, power system quantities under non sinusoidal conditions-harmonic indices-source of harmonics-system response characteristics-effects of harmonic distortion on power system apparatus –principles for controlling harmonics, reducing harmonic currents in loads, filtering, modifying the system frequency response- Devices for controlling harmonic distortion, inline reactors or chokes, zigzag transformers, passive filters, active filters.

Power quality conditioners: Shunt and series compensators, Dstatcom-dynamic voltage restorer, unified power quality conditioners.

Book

1. Ghosh Arindam and Ledwich Gerard, ‘Power quality enhancement using custom power devices’ Springer.
2. Arrillaga J., Watson N. R. and Chen S., ‘Power System Quality Assessment’ Wiley.
3. Caramia P, Carpinelli G and Verde P, ‘Power quality indices in liberalized markets’ – Wiley
4. Angelo Baggini ‘Handbook of Power Quality’ – Wiley.

Optimization Techniques

PSM-104 (a)

Contact: 4L
Credit: 4

Unit I

Fundamentals of optimization techniques: Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Lamda Iteration method, Linear programming, Quadratic programming**).**

Unit II

Lamda iteration method: Brief introduction to lamda iteration method, formulate the Lagrange function, Lamda iteration method to solve Optimal dispatch problem.

Unit III

Quadratic programming: Introduction to quadratic programming, Working principle, sequential programming, Linear constrained optimization problem, Karush-Kuhn-Tucker conditions and its application to solve various problems, Interior point method, lagrangian duality.

Unit IV

Linear programming: Examples of linear programming problem, The Simplex Method I, Fundamental theorem of linear programming, Weak and strong duality theorems, Integer programming, Network flow, develop a linear programming model from problem description.

Unit V

Genetic Algorithm: Introduction to genetic Algorithm, working principle, Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation fitness function. GA operators; Similarities and differences between GA and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm.

Unit VI

Particle Swarm Optimization: Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial

Unit VII

Differential Evolution: Fundamental principle, developing DE based solution techniques for OPF problems with single and multiple objectives and comparing the performance and computational effectiveness of DE with other evolutionary and conventional techniques,

Unit VIII

Application of population based optimization techniques in power systems: Algorithms and flow chart of various optimization techniques for solving economic load dispatch and hydro-thermal scheduling problem.

Reference:

1. S.S.Rao, Engineering Optimization, 3rd Edition, New Age International (P) Ltd.
2. Genetic Algorithm – D.E.Goldberg
3. Principle of soft computing by S.N.Sivanandam & S.N. Deepa
4. Soft computing Technique and its application in electrical Engineering by Chaturvedi,
5. Optimization on Power system Operation by Jizhong Zhu Wiley-IEEE Press.
6. An Introduction to Optimization, 3rd Edition by K.P. Chong, Stanislaw H. Zak.

Soft Computing Techniques

PSM 104 (b)

Contact: 4L
Credit: 4

Module 1

Introduction to Soft Computing, components of soft computing, traditional computing and drawbacks, advantages of soft computing techniques. 2

Module 2

Introduction to fuzzy logic: definition, general idea and importance in practical life. 2

Fuzzy set theory: concept of fuzzy set, membership functions, comparison of fuzzy set and classical set. 6

Operations on fuzzy sets, properties of standard operations, T norm and S norm, Extension principle and application. 4

Height of fuzzy set, core of fuzzy set, support of fuzzy set, normal fuzzy set, normalization of fuzzy set, level set, α cut and strong α cut of fuzzy set, concentration and dilation of fuzzy sets, fuzzy singleton, crossover points. 2

Fuzzy relation: fundamentals of fuzzy relations, operations on fuzzy relations, composition of fuzzy relations, fuzzy reasoning, fuzzy relation inferences, compositional rule of inference, fuzzification. 6

Fuzzy methods in control theory: Introduction to fuzzy logic controller, types of fuzzy logic controllers, basic structure of fuzzy knowledge based controllers, defuzzification methods, applications of fuzzy logic control. 4

Module 3

Introduction to artificial neural networks, artificial neuron model, types of activation functions. 4

Learning in neural networks, feed forward and feedback neural networks, backpropagation training algorithm, Hopfield network, Boltzman machine. 4

Self organizing map, learning vector quantization algorithm. 2

Module 4

Basic concept of genetic algorithm, comparison of GA and traditional techniques, objective function and fitness function, crossover, mutation, GA search, applications of GA. 6

Total **42**

Reference book:

1. Klir, G.J. & Yuan,B.- Fuzzy sets and Fuzzy logic, theory and applications, Prentice Hall of India Private Limited.
2. M. Ganesh - Introduction to fuzzy sets and fuzzy logic, PHI.
3. N. P. Padhy – Artificial intelligence and intelligent systems, Oxford.
4. Timothy J. Ross – Fuzzy logic with engineering applications, Wiley.
5. Nie and Linkens,- Fuzzy Neural Control-Principles, Algorithms and Application, PHI
6. J.S.R. Jang, C.T. Sun, E. Mizutani - Neuro-fuzzy and soft computing, PHI.

7 .Kosco, B.-Neural Networks and Fuzzy System.PH

8. Haykin- Neural Network; A Comprehensive Foundation, PHI

9. Rajasekaran and Pai – Neural Networks , Fuzzy Logic and Genetic algorithms: Synthesis and Application, PHI.

10. Goldberg- Genetic Algorithms, Pearson.

Digital Signal Processing

PSM-104 (c)

Contact: 4L
Credit: 4

Description of Signals and Systems: Types of signals and their characteristics, types of systems and their behavior.

Discrete-time description of signals: Discrete-time sequences, their frequency domain behaviour, comparison with analog signals, convolution of two sequences, sampling a continuous function to generate a sequence, reconstruction of continuous-time signals from discrete-time sequences.

Discrete-time description of systems: Unit-sample response of a system, Time-invariant systems, Superposition principle for linear systems, Stability criterion for discrete-time systems, Causality criterion for discrete-time systems.

Discrete-time Fourier transform: Definition of Fourier transform (FT), important properties of FT, properties of FT for real-valued sequences, use of FT in signal processing, FT of special sequences, the inverse FT, FT of the product two discrete-time sequences

Discrete Fourier Transform: The definition of the Discrete Fourier Transform (DFT), efficient computation of DFT, properties of the DFT.

Digital filter: Definition and anatomy of a digital filter, frequency domain description of signals and systems, replacing analog filters with digital filters, filter categories: IIR and FIR, recursive and non-recursive.

Optimal and adaptive filters: Wiener filtering technique, adaptive filters and their applications.

Spectrum estimation and analysis: Principles, Periodogram method, Blackman – Turkey method, fast correlation method. Autoregressive spectrum estimation.

Wavelet Transforms: Fourier Transform and its limitations, Short Time Fourier Transform, introduction of Continuous Wavelet Transform, Discretization of the Continuous Wavelet Transform (DWT).

Object Oriented Programming
PSM-104 (d)

Contact: 4L
Credit: 4

Objective oriented programming paradigm: Introduction – reusability – security – object oriented programming fundamentals – abstraction -encapsulation - derivation – object oriented languages and packages. 5

Classes and objects: Introduction to C++ - procedural oriented approach to C++ - data types – control structures – problem solving - standard input and output streams – C++ enhancements – function prototypes - defaults reference variables – constants – classes – constructors – destructors – constraint objects – member objects and the functions. 15

Advanced features: Dynamic memory allocation pointers – new and delete operators – classes with pointers – copy constructor – static member – friend classes – friend functions – operator overloading. 10

Polymorphism and inheritance: Function overloading – connection classes – derived classes – class conservation – protected members – virtual functions – dynamic binding – abstract classes – multiple inheritance – templates error handling. 10

Case studies: Overview of typical object oriented systems – case studies – application to electrical engineering. 5

Reference:

1. Stanley B. Lipman , C++ primer, Addison Wesley, 1989
2. Bertrand Meyar, Object softwere construction, Prentice Hall, 1988
3. K.R. Dittrich et al , On object oriented data base system , Springer Verlag , 1991

Power System Operation and Control

PSM-201

Contact: 4L
Credit: 4

Optimal Generation Scheduling: Power flow scheduling using economic load dispatch, power flow scheduling using Lagrange multiplier method, penalty factor, scheduling with network losses, hydrothermal coordination with and without losses, cascaded and pump storage plant scheduling, unit commitment, unit commitment solution methods, introduction to optimal power flow solution using Newton Raphson method. 12

Automatic Generation Control: Types of alternator exciters, automatic voltage regulators for generator excitation control, static and dynamic performance of AVR loop, automatic load frequency control, primary automatic load frequency control loop, secondary automatic load frequency control loop, extension of automatic load frequency control loop to multi area systems, tie line power flow model. 12

Power System Security: Security analysis, security assessment, contingency analysis, algorithm to determine system security following contingency analysis procedure, security assessment using ac power flow model, security analysis using concept of performance index. 6

State Estimation and load forecasting: Methods of state estimation – least square and weighted least square estimation, bad data detection and suppression of bad data, load forecasting, load forecasting techniques – methods of extrapolation and correlation, estimation of average and trend terms of deterministic part of load – limitation of the method, prediction of deterministic load, generalized load modeling, estimation of periodic components, estimation of stochastic part of load – time series approach. 12

Books:

1. Power System Analysis, Operation and Control, Abhijit Chakrabarti and Sunita Halder PHI.

2. Power Generation Operation and Control, Allen J. Wood, Bruce F. Woolenburg

Power System Instrumentation

PSM–202

Contact: 3L+1T
Credit: 4

Introduction: Power generating Station – Thermal, Hydel, Nuclear, Wind – Their functional characteristics as processes, Components of power Grid – interdependency between different blocks, Review of Mechanical, Electrical, Electronics, Thermal, Optical, Pneumatic, fluidics. 6

Thermal Power Generation:

(a) Coal handling plant – coal feed rate measurement, determination of calorific value.
(b) Water treatment
(c) Boiler – Feed water, pressure, temperature, steam flow rate, flue gas analysis, optical pyrometer
(d) Turbine – Speed, shaft eccentricity, temperature
(e) Condenser – pressure, temperature
(f) Generator – Speed, hydrogen leakage
(g) Control and protection systems of a thermal power plant.
(h) Thermal power generation from nuclear reactor.
(i) Ash handling and pollution control 14

Hydel Power Plant: Types - flow rate, Water pressure 2

Wind Power: Principles – synchronization with grids 1

Transformer: Transformer oil, hot spot, moisture detection, 2

Transmission Lines: Fibre optics meter for high voltage and high current measurement, Transmission line sag measurement using triangulation technique. 2

Tariff: Objective, Available based tariff, Digital energy meter, Remote terminal unit (RTU) 3

Local Dispatch Centre: Data handling – Processing, Logging, Acquisition, Accounting, Display and Storage, SCADA, Techniques of Data acquisition at Central Load Dispatch Centres for coordinated control of the grid.
6

Computer Control of Power Plant:

IS specification: Introduction, Application and Relevancy of IS specification in perspective of power system instrumentation.
2

Reference:

1. Modern Power Station Practice – Vol: C, Vol: D, Pergamon Press
2. Principles of Industrial Instrumentation - D Patranabish, TMH, New Delhi
3. Industrial Instrumentation Control and Automation – S Mukhopadhyay, S.Sen, A. Deb – Jaico Publishing House, Mumbai.
4. B. G. Liptak, Instrument Engineers Handbook, Chilton Book Co. Philadelphia

Advanced Power System Protection

PSM-203

Contact: 4L

Credit: 4

Introduction: Protective Relays; Basic requirements and type of protection, reviews of relay characteristics and operating equations, protective CTs, PTs, , phase and amplitude comparator, classification of Electromagnetic relays, Plug Setting Multiplier and Time Multiplier setting, Universal Torque Equation, Non Directional Relay, Directional relay, Distant relay, Differential relay. 8

Protection of Alternators: Protection against Stator fault (Phase to Phase and Phase to Ground), Balanced earth fault protection, Stator inter turn protection, Unbalanced loading of Alternator, Prime Mover failure, Overvoltage protection, Overloading (or over current) Protection, Restricted Earth fault and standby earth fault protection, Rotor Fault Protection. 4

Protection of Transformer: Overcurrent and unrestricted Earth fault protection, Different CT connections, Balanced (Restricted) earth fault protection, Harmonic restraint, Frame leakage protection 3

Bus bar, Feeder, Transmission line Protection:

Bus bar Protection: Circulating Current Protection, Frame Leakage Protection.

Feeder protection: Time Graded protection, Differential Protection.

Transmission Line Protection: Introduction to distance relay, Simple Impedance relay, Reactance relay, Mho relays, comparison of distance relay – Choice between Impedance, Reactance and Mho relay, High speed Impedance relay, setting of distance relays.

Pilot Relaying Schemes: Wire Pilot Protection, Carrier Current Protection. 10

Static Relay

Introduction: Basic construction of static relays, advantages and disadvantages of Static Relay, different types of static relays (static overcurrent, static time overcurrent, static instantaneous overcurrent, directional static overcurrent, static differential and static distance relay) comparators and associated elements, system switching and transient effects. 6

Protection of High Voltage Capacitor Bank: Including consideration of inrush current, over current and over voltage, and differential protection scheme. 2

Protection Of large Motors: Differential protection, Earth fault Protection, Thermal overload protection, Starting and Stalling currents and effect of negative Sequence current. 3

Digital Relay: Introduction, protection philosophy, basic hardware and protection schemes, protection algorithms, microprocessor based digital relaying. 4

Text Books:

1. A. Chakrabarti,M.L. Soni, P. V. Gupta, U. S. Bhatnagar "A text book on Power System Engineering", Dhanpat Rai and Co.

2. Paithankar.Y.G and Bhide.S.R, "Fundamentals of Power System Protection", Prentice-Hall of India.

3. Badri Ram and Vishwakarma.D.N, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company, 2002.

4. Arun K. Phadke, James. S. Thorp, "Computer relaying for Power system", John Wiley and sons, New York, 1998.

Reference:

1. Power System Protection, PM Anderson, IEEE Press Book
2. Protective Relays Application and Guide, GEC Measurements
3. Jones D., " Analysis and protection of electrical power systems", Pitman Publishing, 1971.
4. " Power system reference manual, Ray rolls protection", Orient press, 1982.
5. Stanley H., Horowitz (ED), "Protective relaying for power system", IEEE press, 1980.

Power System Transients
PSM-204(a)

Contact: 4L
Credit: 4

Introduction and survey: Review of various types of power system transients – effect of transients on power systems – relevance of the study and computation of power system transients. 5

Lighting surges: Electrification of thunderclouds – lightning current surges – lightning current parameters and their values – stroke to tower and midspan – induced lightning surges. 10

Switching surges: Closing and reclosing of lines – load rejection – fault initiation – fault clearing – short line faults – Ferro – resonance – isolator switching surges – temporary over voltages – surge on an integrated system – switching – harmonics. 10

Computation of transient in conversion equipment: Travelling wave method – Beweley's Lattice diagram – analysis in time and frequency domain – eigen value approach – Z-transform – EMTP software. 10

Insulation coordination: Over voltage protective devices – shielding wires, rods gaps and surge diverters, principles of insulation co ordination-recent advancements in insulation co ordination – design of EHV system. 10

References:

1. Allan Greenwood, Electrical transients in Power Systems, Wiley Interscience, New York, 1971.

2. Klaus Ragaller, Surges in High Voltage Networks, Plenum Press, New York, 1980.

3. Diesendrof W., Over Voltages On High Voltage Systems, Renselaer Bookstore, Troy New York, 1971.

4. Peterson H.A., transients in power systems, Dover Publications, New York, 1963.

5. Rakosh Das Begamudre, Extra High VoltageAC Transmission Engineering, Wiley Estern Itd, New Delhi, 1990.

6. www.abb.com

7. www.microtran.com

Flexible AC Transmission System
PSM-204(b)

Contact: 4L
Credit: 4

Introduction: FACTS – a toolkit, basic concepts of static VAR compensator, Resonance Damper, thyristor controlled series capacitor, static condenser, phase angle regulator and other controllers. 9

Series compensation schemes: Sub-synchronous resonance, torsional interaction, torsional torque, compensation of conventional, ASC, NGH damping schemes, modeling and control of thyristor controlled series compensators. 9

Unified power flow control: Introduction, Implementation of power flow control using conventional thyristors, Unified power flow concept, Implementation of unified power flow controller. Phasor Monitoring Units; Power System Control using Synchrophasors. 9

Design of facts controllers: Approximate multi-model decomposition, variable structure FACTS controllers for power system transient stability, non-linear variable-structure control, variable structure series capacitor control and variable structure resistor control. 9

Static var compensation: Basic concepts, thyristor controlled reactor(TCR), Thyristor Switched Reactor(TSR), Thyristor Switched capacitor(TSC), saturated reactor(SR), fixed capacitor(FC). 9

References:

1. Narin G. Hingorani, Flexible AC transmission, IEEE Spectrum, April 1993, pp40-45.

2. Narin G. Hingorani, High Power Electronics and flexible Ac Transmission systems, IEEE High Power Engineering Reiview, 1998.

3. Narin G. Hingorani, Power Electronics in Electric Utilities: Role of Power Electronics in future power systems, Proc.of IEEE, IEEE, Vol.-76, No.-4, April 1988.

4. Einar V Larsen, Juan J. Sanchez-Gasca, Joe H. Chow, Concepts for design of FACTS Controllers to damp Power Swings, IEEE Trans on Power Systems, Vol.-10, No.-2, May 1995.

5. Gyugyi L., Unified Power Flow Control Concept For Flexible Ac Transmission, IEEE Proc-C Vol.-139, No.-4 July 1992.

Advanced Electrical Drives

PSM-204(c)

Contact: 4L
Credit: 4

Power devices and Motor Drive: An introduction to modern electrical drives, Power devices and their switching , Electric machines, Power converters , controllers and load

Reference frame theory and transformation: Three phase transformation, abc-axis to dq-axis transformation, space vector and transformation

Modeling and Control of DC Machines: Electromechanical modelling, state-space modelling

Block diagram and transfer function, Control of separately excited dc motor drives for Inner current loop and speed control design

Speed control of Induction motor (IM) drives: V/f control, dq0 model and state space model of three phase IM, Vector control of IM, Direct torque control (DTC) of induction motor drives, Comparison of DTC and Vector control

Brushless DC motor drives and an introduction to Microcontroller based control of electrical drives: Brushless DC motor drives, Introduction of Microcontroller and DSP based control of electrical drives and some industrial applications

Reference Books:

1. B.K. Bose: Modern Power Electronics and AC Drives, 1st Edition, Pearson, 2002

2. Bin-Wu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006

3. R. Krishanan: Electric Motor Drives Mode

Advanced Control System
PSM-205 (a)

Contact: 4L
Credit: 4

Overview of Control Systems: LTI Motion Control System; Temperature & Voltage Regulators; Modeling of Servo-motors, Hydraulic & pneumatic actuators. Computation of Relative stability using Bode plot and Nyquist method. Hierachical Control Of Power System; System Control; Load scheduler and Optimiser; Real Reactive power Flow Control; AVR and Turbine Speed governor set points. 6

Control System Performance: Improvement of System Performance through Compensation; Design of lag; Lead and Lag load Compensators; PI, PD & PID control; PID Controller Design and tuning; Disturbance rejection; System Uncertainty and performance Robustness. 6

Analysis in state space: State model for SISO & MIMO Systems; State Diagram; Solution of state equation; State Transformations; Jacobian Linearization Technique; Stability; Controllability & Observability; Perspective on State-Space design; Full-State Feedback Design of continuous time control system; Full Order observer System. 6

Digital Control system: Configuration of Digital Control System; Supervisory Control; Direct digital control; Single-Loop Digital controllers; Sampling Process; Sampling theorem; Data reconstruction; Digital transfer function & System response; Stability Tests ; Mapping between s-plane & z-plane; Bilinear transformation; Error constants; Pole assignment design based on full state feedback; Compensator design in w-plane using Bode plot. 10

Non-linear System: Common non-linearities ; Methods of Analysis; Linearization; Phase Plane method; Describing function Analysis; Limit Cycles; Relay with dead-zone and hysteresis; Stability analysis by Lyapunov's methods. 6

Optimal Control: Characteristics of optimal control problems; Linear optimal Control with quadratic performance index; Selection of performance measure; State and Output regulators; Optimal state regulator problem with matrix Ricatti equation. 6

Reference books:

1. Ogata, k – modern control engineering, p.h learning.
2. Kuo, b.c – automatic control systems, prentic hall.
3. Roy chowdhury, d – modern control engineering, prentic hall.
4. Nagrath i.j, gopal m – control system engineering, new age publishing.
5. Gopal, m – digital control and state variable methods, tata mcgraw -hill.
6. Kuo, b.c. – digital control system, oxford university press.
7. Franklin f, powell j.d, emami naeini, a- feedback control of dynamic systems, addision weslay publication.
8. Peter dorato – robast control.
9. Gibson, j.e. – non-linear system, mcgraw –hill.

Modeling and Simulation of Dynamic Systems

PSM-205(b)

Contact: 4L
Credit: 4

Module 1: Introduction, State space representation of systems of different kind.Simulation of the state model.Describing equations and different kinds of models.Eigen values and vectors, Similarity X'formation, invariants.Stability, controllability, observability, Leverrier's algorithm. Linearization of nonlinear systems

Module 2: Theorem on feedback control, pole placement controller. Full order and reduced order observer design. Theory of industrial regulation, feed forward control. Application - motor speed control with disturbance rejection.

Module 3: Heat flow in one dimension, finite element method. Modeling and simulation through bond graphs. Qualitative reasoning: M & S with Incomplete Knowledge.

Module 4: Sensor modeling: Lumped parameter and distributed parameter models, Thick and thin film models. Numerical modeling techniques, model equations, application of Finite Element method. Different effects on modeling - temperature, radiation, mechanical, chemical, magnetic, electrical (e.g. capacitive, resistive, piezo-resistive, frequency, etc.). Examples of modeling: micro-modeling of photodiodes, magnetic, capacitive, mechanical sensors.

Reference Books:

1. D M Wiberg State Space and Linear Systems Schaum's Outline Series McGraw Hill 1971

2. W B J Zimmerman Process Modeling and Simulation with Finite Element Methods Univ. of Sheffield UK 2004

3. Amalendu Mukherjee and RanjitKarmakar Modeling and Simulation of Engineering Systems through Bond Graphs Narosa New Delhi 1999

4. Benjamin Kuiper Qualitative reasoning: Modeling and Simulation with Incomplete Knowledge MIT Press Cambridge Mass 1994

5. Thomas Kailath Linear Systems Prentice Hall 1980

6. Robert D. Strum and Donald E. Kirk Contemporary Linear Systems Using Matlab Thomson Learning1999

7. M Gopal Modern Control System Theory Wiley Eastern 1984

8. M Gopal Digital Control Engineering Wiley Eastern 1988

9. K Ogata Modern Control Engineering 4th edition Prentice Hall 2002

10. B C Kuo Automatic Control Systems 7th Edition Prentice Hall 1995

11. Patranabis, D.- Sensors and Transducers. 2nd edition, PHI, New Delhi,

12. Ghosh, M. K. et al (ed) - Trends in.....

13. Learning MATLAB and Simulink Mathworks

14. Grandke, T. and Ko, W.H.(ed) - Sensors: Fundamentals and General Aspects. Vol I of Sensors: A Comprehensive Survey. VCH, Germany, 1989

Advanced Microprocessor and Microcontroller
PSM 205 - (d)

Contact: 4L
Credit: 4

Introduction: Review of Intel 8085 and 8086 – Architecture and Organization 2

Components and functions: Execution Unit, Bus Interface Unit, Registers, Minimum and Maximum Mode of Operation, Bus Arbiter, Interrupt Structure, Interrup Vector Table, I/O Ports, Experimental identification of Ports and Pins. 10

Peripheral devices: PPI 8255, Mode 0, Mode 1, Mode 2 and BSR Mode. Interrupt Controller, DMA Controller, ADC, DAC 5

Development of waveforms: Square, Triangular, Ramp, Staircase, Sinewave. 3

Relays: Microprocessor based Electromagnetic Relays, IDMT, Differential Relay. 4

Instrumentation & protection (smart grid): Microprocessor based Voltage, Current, Power and Speed measurement, Frequency Monitoring, Overvoltage, Undervoltage, Overcurrent and Undercurrent protection, Speed Control of Motors, Traffic Light Controller, Washing Machine Controller. 12

Microcontroller: Architecture, Organization and Programming Techniques. 4

References:

1. A. K. Mukhopadhyay - Microprocessor, Microcontroller and their Applications, Narosa Publishing / Alpha Publication, Oxford University

2. A. K. Mukhopadhyay – Microprocessor based Laboratory experiments and Projects, I. K. International

3. Microprocessor and Microcontroller - Gaonkar

4. Anokh Singh, A. K. Chhabra - Fundamentals of Microprocessors and its Applications, S. Chand Publishers

EMM 301 - **Basics of Pedagogy and Academic Management** (4 0 0) 4 credits

Module 1 **12**

Fundamentals of Pedagogy - Psychology of learning – Introduction – Theories of Learning – Memory and Forgetting – Personality and Attitude – student Motivation.

Class room management - Effective Classroom Communication - Classroom Motivation principles and techniques - Techniques of Class room management.

Student evaluation - Principles of evaluation - Tools and techniques of evaluation - Statistical analysis of evaluation process.

Student feedback - Tools and techniques - Evaluation of teacher performance

Module 2. **6**

Research methodology and tools - Definition of research and research methodology - objectives and types research - criteria of a good research.

Data collection – primary data (questionnaire, interview, etc.) and secondary data (case study, journals, etc.) – sampling - census and sample survey - need for sampling - characteristics of a good sample - criteria of selecting sampling procedure - different types of sample design

Data analysis - frequency distribution - measures of central tendency - correlation and regression (concepts only)

Research proposal - selection of topic - literature survey - development of hypothesis - hypothesis testing (concepts only)

Report writing - Interpretation and report writing – techniques of interpretation - significance of report writing - different steps in report writing and format for report writing.

Plagiarism in research.

Module 3. **6**

Intellectual Property Right and Patent Laws in India

What is intellectual property - importance of IPR. Patent -types of patents - patentable inventions - what is not patentable - application and registration of patents - who can apply - rights and duties of patentee - infringement and remedies.

Copyright - coverage provided by copyright - Transfer of copyright - Infringement of copyright

Trademark - Well-known trademarks and associated trademarks - Service marks - Certification Trademarks.

R & D activities in educational institutes – IPR and patent issues.

Module 4. **12**

Academic Institution Management - Organisation - Types- structure-Institution as an organisation

Institutional process - objectives - purpose - responsibilities

Management - fuctions - skills - motivational theories- communication- types- nature- importance-channel richness - how to increase effectiveness of organisational communication. Transparency in academic institutions.

Quality-concept-deciphering quality aspect of different products, services as also that of educational system and institutions

Quality improvement in institutional activities - identification of potential areas

Washington Accords – goal – salient features - implications

Customer – different classes - orientation – satisfaction of stake holders

Basics of project management - concept - types - life - cycle - phases - feasibility - viability - cost benefit analysis – PERT and CPM – SWOT Analysis -dimensions of educational projects – case studies

Text Books

1. Rao and Reddy - Learning & Teaching, , Commonwealth Publishers, New Delhi, 1992
2. Chauhan S S - Advanced Educational Psychology, Vikas Publishing House Pvt. Ltd, 2002
3. Cooper J.M.(Ed) - Classroom Teaching Practice, D.C.Heath and Co
4. Romiszwoski A J - Designing Instructional Systems, Kogan Page
5. Gronlund N E - Measurement and Evaluation in Teaching, Macmillan Publishing Co., New York, 1981
6. Kulkarni M V - Research Methodology, EPH
7. Das N G – Statistical Methods (Vol I and II), M Das and Co.
8. Natarajan, S - Introduction to Economics of Education, Sterling Publishers, New Delhi
9. Rao Usha – Education Technology, Himalaya Publishing House, Delhi.
10. Hirwade and Hirwade – Fundamentals of Intellectual Property Right, Himalaya Publishing House, Delhi.
11. Pandya S R – Administration and Management of Education, Himalaya Publishing House, Delhi.
12. Chary S N – Production and Operations Management, TMH

Reference Books

1. Saylor A. and Lewis H - Curriculum Planning for Better Teaching & Learning, Rinehart & Winston, Inc., 1981.
2. Beard I. J. and Senior I. J. - Motivating Students, Routledge & Kegan Paul Ltd, 1980.
3. Barnard H C - An Introduction to Teaching, University of London Press Ltd., London, 1965
4. Bigge M L - Learning Theories for Teachers, Harper & Row, Publication, New York, Second edition, 1971
5. Heywood J - Pitfalls and Planning in Student Teaching, Kogan Page
6. Reay G D - Selecting Training Methods, Kogan Page Ltd., London, 1994
7. Lorin W A - The Effective Teacher, McGraw-Hill Book Company, 1981.
8. Brown G - Lecturing & Explaining, Methuen & Co.
9. Cohen L and Manion L - A Guide to Teaching Practice, Methuen & Co
10. Romiszwoski A J - Producing Instructional Systems, Kogan Page
11. Betrand A and Cebula J P - Tests, Measurement and Evaluation – A Developmental Approach, Addison – Wesley Publishing Company, Philippines, 1980.
12. Taylor B, Sinha G and Ghoshal T - Research Methodology, Prentice Hall of India.
13. Chakraborty S K – Business Statistics New Age International Publishing.
14. Trochim W M K – Research Methods, Biztantra
15. Sallis E - Total Quality Management in Education, Kogan page, London,1996.
16. Bulchandani K R -: Business Law, Himalaya Publishing.
17. Gopalkrishnan and Ramamoorthy - Text Book of Project Management; McMillan
18. Chandra, P – Projects, TMH, 6th Edition.

Non conventional Energy
PSM 301 - (a)

Contact: 4L
Credit: 4

Introduction to solar energy: Recent trends in energy consumption – World energy scenario – Energy sources and their availability – Need to develop new energy technologies – Solar radiation and measurement – Solar cells and their characteristics – Electrical storage with batteries – Production and transfer of solar energy – Sun-Earth angles – Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation – Solar thermal collectors – General description and characteristics – Flat plate collectors –Short term and long term collector performance – Solar concentrators – Design, analysis and performance evaluation. – Analysis of PV systems.

Wind energy conversion system: Basic principle of wind energy conversion – nature of wind – Wind survey in India Site selection considerations– Power in the wind –components of a wind energy conversion system -Types of wind power conversion systems – Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis Performance of Induction Generators for WECS – Classification of WECS.

Bio-mass energy: Biomass: Generation and utilization, Properties of biomass, Agriculture Crop & Forestry residues used as fuels. Biochemical and Thermo-chemical Conversion, Combustion, Gasification, Biomass gasifiers and types etc. Concept of Bio-energy**:** Photosynthesis process, Biomass resources Bio based chemicals and materials Thermo-chemical Conversion: Pyrolysis, Combustion, Gasification, Liquification. Bio-Chemical Conversion: Aerobic and Anaerobic conversion, Fermentation etc.
Bio-fuels: Types of Bio-fuels, Bio fuel applications, Ethanol as a fuel for I.C. engines, Importance of biogas technology, Different Types of Biogas Plants. Aerobic and anaerobic bioconversion processes, various substrates used to produce Biogas. Removal of CO_2 and H_2O, Bio-hydrogen production.

Geothermal, tide and wave energy: Availability of Geothermal Energy-size and Distribution, Recovery of Geothermal Energy, Various Types of Systems to use Geothermal Energy, Direct heat applications, Power Generation using Geothermal Heat, Sustainability of Geothermal Source, Status of Geothermal Technology, Economics of Geothermal Energy.

Power conditioning converters: DC Power conditioning converters – Maximum Power point tracking algorithms – AC power conditioners – Line commutated inverters – synchronized operation with grid supply – Harmonic problem

Text/References:

1. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003
3. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.
4. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Printice Hall, 2000.
5. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002
6. Rai G.D., "Non – Conventional Energy Sources", Khanna Publishers, 1993.
7. Rai G.D., "Solar Energy Utilisation", Khanna Publishers, 1993.
8. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985.

Power System Harmonics

PSM 301 - (b)

Contact: 4L
Credit: 4

1. **Harmonic Analysis:** Representation of harmonics, Fourier series and Coefficients, odd, even and half wave symmetry, phase sequence. Measures of harmonic distortion: voltage and current distortion factors, active and reactive power, apparent power, distortion power, power factor, current and voltage crest factors. Power in passive elements: power in a pure resistance, power in a pure inductance and power in a pure capacitance. Series and parallel resonance. 12

2. **Harmonic Sources:** Types of harmonic sources, Harmonic in transformers, normal excitation characteristics, determination of current waveshape in transformers, inrush current harmonics in transformers, Harmonic in rotating machines: mmf distribution of ac windings, slot harmonics, voltage harmonics produced by synchronous machines, rotor saliency effects, voltage harmonics produced by induction motors. Distortion caused by arcing devices: Electric arc furnaces and discharge type lighting. Distortion caused by dc power supplies. 10

3. **Effects of Harmonic Distortion in Power Systems:** Thermal losses in harmonic environment: Copper losses, iron losses, dielectric losses. Harmonic amplification in capacitor banks. Effects of harmonics in transformers. Effects of harmonics in rotating machines: induced emf, chorded windings, distributed winding, winding factor. Harmonic interference with power system protection: harmonic problems during fault conditions. Effects of harmonics on consumer equipment. Interference with Communications. 8

4. **Limits of Harmonic Distortion:** Voltage harmonic distortion limits: IEEE limits, IEC limits EN limits and NORSOK limit. Current harmonic distortion limits: IEEE limits IEC limits and NORSOK limits. 2

5. **Elimination of Power System Harmonics**
   Passive filters: Tuned filters and damped filters
   Active filters: Series and parallel connection of active filters
   Role of power converters, transformers, rotating machines and capacitor banks in reduction of harmonics.
   Harmonic filter design: Series tuned filters and second order damped filters. 8

Reference Books:

1. "Power System Harmonics" by J. Arrillaga and N. R. Watson, Wiley
2. "Power Systems Harmonics" by George J. Wakileh, Springer

Energy Management & Audit

PSM 301 - (c)

Contact: 4L
Credit: 4

Introduction: Energy Scenario – global, sub continental and Indian, Energy economy relation, Future energy demand and supply scenario, Integrated energy planning with particular reference to Industrial Sector in India, Captive power units and others – demand v/s supply. 4

Types of Energy: Physical Aspects of Energy: Classification of energy – Hydel, Thermal, Nuclear, Wind, & from Waste Products. Efficiency and effectiveness of energy utilization in Industry. Energy and energy analysis. Renewable and non-renewable energy, Conventional and unconventional energy. 4

Demand Side Management:
Energy Demand Management:
Energy utilization, Instrumentation and data analysis, Financial aspects of energy management, Energy management as a separate function and its place in plant management hierarchy.

Energy Planning, Energy Staffing, Energy Organization, Energy Requirement. Energy Costing, Energy Budgeting, Energy Monitoring, Energy Consciousness, Energy Conversions, Energy Efficient Equipment, Energy Management Professionals, Environment Pollution due to Energy Use, Components of Pollution, Harmful Effects of Pollution, Measures taken to combat Pollution. 6

Energy Audit and Energy Saving: Energy Audit and analysis, Energy load measurements, System evaluation and simulation, Energy saving techniques and guidelines: Administrative control, Proper Measurement and monitoring system, Process control, proper planning & scheduling, Increasing capacity utilization, Improving equipment control, waste heat recovery, Change of energy source. Upgradation of Technology. Change of product specifications, Use of High efficiency equipment, Design modification for better efficiency, Improved periodic maintenance; 6

Energy Control Centers: Remote Telemetry; Remote Terminal Units; IEC TC 57 (870-5-1) Protocol Standard; Data Acquisition Procedure; Data Handling and Organization; Real Time Database; Alarm and Events; Disturbance Processing; Fault Locating Technology; Real Time Display; MIMIC Boards; Supervisory Remote Control; Load Dispatch Control Centers; Distribution Control Centers; Time Keeping Systems; 10

Integration of Distributed and Renewable Energy Systems to Power Grids: DC-to-AC Converters; AC-to-AC Converters; DC-to-DC Converters; Plug-In Hybrid Electric Vehicles; Energy Storage Technologies; Microgrids; 6

Legal Provisions: The Prevention and Control of Pollution Act, 1974, The Energy Conservation Act, 2001, The Environmental Protection Act, 1986. The Electricity Act, 2003. National Electricity Policy. Rural Electrification. 4

Reference Books:

1. Paul W., O'callaghan; "*Energy Management"*, McGraw Hill Book Company
2. Steve Doty, Wayne C. Turner; "*Energy Management Handbook"*, Fairmont Press Inc., GA 30047
3. Barny L. Capehart, Wainey C. Turner, William J. Kennedy; "*Guide to Energy Management*", Fairmont Press Inc., GA 30047
4. Handbook of Energy Engineering, Albert Thumann & Paul Mehta, The Fairmont Press, INC.
5. NPC energy audit manual and reports
6. Cleaner Production – Energy Efficiency Manual for GERIAP, UNEP, Bangkok prepared by National Productivity Council
7. www.bee.org

Section 6: Power Systems. Basic concepts of electrical power generation, ac and dc transmission concepts, Models and performance of transmission lines and cables, Series and shunt compensation, Electric field distribution and insulators. Distribution systems, Perâ€unit quantities, Bus admittance matrix, Gauss- Seidel and Newton-Raphson load flow methods, Voltage and Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis.Â But the general aptitude section has a common syllabus for both subjects. Moreover, some of the topics from engineering mathematics could also be similar in both subjects. The core GATE 2021 syllabus for Electrical engineering is EE in Power Systems. West Bengal University of Technology 1. st.Â Non-linear System: Common non-linearities ; Methods of Analysis; Linearization; Phase Plane method; Describing function Analysis; Limit Cycles; Relay with dead-zone and hysteresis; Stability analysis by Lyapunovâ€™s methods. 6. Optimal Control: Characteristics of optimal control problems; Linear optimal Control with quadratic performance index; Selection of performance measure; State and Output regulators; Optimal state regulator problem with matrix Ricatti equation. IES/ESE 2021 Syllabus & Paper Pattern â€“ Electrical Engineering. In 2017, Union Public Commission (UPSC) proposed a new scheme for Indian Engineering Service (IES/ESE) Examination. Based on this GATExplore provide you IES/ESE 2021 Syllabus for Electrical Engineering & Paper Pattern. Contents.Â (Stage I â€“ Paper I, Objective type, Common to all Candidates, 2 hours duration, 200 Marks maximum). The questions from the following Topics will be set in Paper-I of Stage-I.Â Electrical Engineering. Contents for syllabi of both the Papers together for Preliminary Examination/Stage-I (objective type Paper-II) and separately for Main/Stage-II Examination (Conventional type Paper-I and Paper-II). PAPER â€“ I. Engineering Mathematics. M. Tech. Programme in. Power electronics. Syllabus for. CREDIT BASED UNIFORM CURRICULUM (Applicable for 2015 batch onwards). Department of Electrical and Electronics Engineering National Institute of Technology. Tiruchirappalli â€“ 620015 tamilnadu india.Â Industrial and commercial distribution systems â€“ Energy losses in distribution system â€“ System ground for safety and protection â€“ Comparison of O/H lines and underground cable system - Network model â€“ Power flow - Short circuit and loss calculations. Distribution system - Reliability analysis â€“ Reliability concepts â€“ Markov model â€“ Distribution network reliability â€“ Reliability performance.Â EE619 Transient over voltages in power systems. L T p C 3003. Course Objectives