GOA UNIVERSITY

Scheme of Teaching and Examination for
Master of Engineering (Power and Energy System Engineering)
Two years Full time Course

Semester-I									
Subject Code	**Subject**	**Hours per week**			**Scheme of Examination**				
		L	**T**	**P**	**Theory (Hrs)**	**Credits**			
						Theory	**IA**	**Pract**	**Total**
MPE 1.1	Energy Conversion systems	4	-	-	3	4	2	-	6
MPE 1.2	Analysis of Power Converters	4	-	-	3	4	2	-	6
MPE 1.3	Advanced Power System Analysis	4	-	-	3	4	2	-	6
MPE 1.4	Elective-I	4	-	-	3	4	2	-	6
MPE 1.5	Elective -II	4	-	-	3	4	2	-	6
MPE 1.6	Power Engineering lab-I	---	---	4	--	---	2	2	4
	Total	**20**	**-**	**4**		**20**	**12**		**34**

Semester-II									
Subject Code	**Subject**	**Hours per week**			**Scheme of Examination**				
		L	**T**	**P**	**Theory (Hrs)**	**Credits**			
						Theory	**IA**	**Pract**	**Total**
MPE 2.1	Advanced Power System Protection	4	-	-	3	4	2	-	6
MPE 2.2	Power Electronics control of Drives	4	-	-	3	4	2	-	6
MPE 2.3	Energy Auditing, Conservation and Management	4	-	-	3	4	2	-	6
MPE 2.4	Elective-III	4	-	-	3	4	2	-	6
MPE 2.5	Elective -IV	4	-	-	3	4	2	-	6
MPE 2.6	Power Engineering lab-II	---	---	4	-	--	2	2	4
	Total	**20**	**-**	**4**		**20**	**12**	**2**	**34**

Semester-III										
Subject Code	**Subject**	**Hours per week**			**Scheme of Examination**					
		L	**T**	**P**	**Theory (Hrs)**	**Marks**				**Credits**
						Theory	**IA**	**Pract**	**Oral**	**Total**
MPE 3.1	Distribution Automation	4	-	--	3	4	2	-	--	6
MPE 3.2	Elective-V	4	-	--	3	4	2	-	--	6
MPE 3.3	Project	---	---	12	--	----	4	-	4	8
MPE 3.4	Seminar-I	---	---	8	--	----	2	-	2	4
	Total	**8**		**20**		**8**	**10**		**6**	**24**

Semester-IV									
Subject Code	Subject	Hours per week			Scheme of Examination				
		L	T	P	Theory (Hrs)	Marks			Credits
						IA	Pract	Oral*	Total
MPE 4.1	Dissertation	---	----	24	--	10	-	12	22
	Total	**-**	**-**	**24**		**10**	**-**	**12**	**22**

Grand Total of all four semesters	**48**	**-**	**54**	**48**	**44**	**4**	**18**	**114**

All Theory papers of 100 marks

Note:-* Examination panel shall be constituted of chairman with Head of Electrical and Electronics Engineering Department or his nominee if head is the guide or if head cannot be present, the guide and another examiner preferably from outside the university.

Elective lists

ELECTIVE –I (MPE1.4)

- i) Advanced Digital Signal Processing
- ii) Transient Over voltages in power system
- iii) Flexible AC Transmission systems
- iv) Distribution system design & control
- v) Energy System Modeling and analysis

ELECTIVE-II (MPE 1.5)

- i) Power system Dynamics
- ii) Extra High Voltage transmission
- iii) Optimization techniques
- iv) Utilization of Solar Thermal energy
- v) Digital simulation of Power Electronic Systems

ELECTIVE-III (MPE 2.4)

- i) High Voltage D C Transmission
- ii) Power Quality
- iii) Power system Planning & Reliability
- iv) Economic Operation of Power systems
- v) Economics & planning of Energy Systems

ELECTIVE –IV (MPE 2.5)

- i) Special Electrical Machines
- ii) Design and development of Power Modules
- iii) Power system Instrumentation
- iv) ANN applications in Power System Engineering
- v) Wind Energy Conversion Systems.

ELECTIVE –V (MPE 3.2)

- i) Computer aided design of Electrical apparatus
- ii) Embedded control of electrical Drives
- iii) Restructured power systems
- iv) Energy Resources, Economics and Environment
- v) Power from Renewable & Environmental aspects

SEMESTER I

MPE 1.1 ENERGY CONVERSION SYSTEMS

I. Photo voltaic (PV) power generation, spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

II. Principles of Magnetic Hydro Dynamic (MHD) power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

III. Wind Energy conversion: Power from wind, properties of air and wind, types of wind Turbines, operating characteristics. Tides and tidal power stations, Modes of operation, tidal project examples, turbines and generators for Tidal power generation. Wave energy conversion: properties of waves and Power content, vertex motion of Waves, device applications. Types of Ocean thermal energy conversion systems Application of OTEC systems Examples, micro hydel developments.

IV. Miscellaneous energy conversion systems: coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, fuel cells and batteries, principles of EMF generation, description of fuel cells, description of batteries, battery application for large powers.

V. Co-generation and energy storage, combined cycle co-generation, energy storage. Global energy position and environmental effects: energy units, global energy position. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

REFERNCE BOOKS

1. Energy conversion systems by Rakosh Das Begamudre, New age international publishers, New Delhi - 2000.
2. Wind electrical systems by S. N. Bhadra & S. Banerjee, Oxford University Press
3. Wind Energy Systems for Electric power Generation by Stiebler, Springer

MPE 1.2 ANALYSIS OF POWER ELECTRONIC CONVERTERS

I. Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads – ac voltage controllers with PWM Control – Effects of source and load inductances - Synchronous tap changers- Applications - numerical problems.

II. Three phase AC voltage controllers – Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads – Effects of source and load Inductances – applications – numerical problems.

III. Single phase to single phase cycloconverters – analysis of midpoint and bridge Configurations – Three phase to three phase cycloconverters – analysis of Midpoint and bridge configurations – Limitations – Advantages – Applications- numerical problems.

IV. **S**ingle phase converters – Half controlled and Fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – single phase dual converters – power factor Improvements – Extinction angle control – symmetrical angle control – PWM – single phase sinusoidal PWM – single phase series converters – Applications - Numerical problems.

V. Three phase converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – three phase dual converters – power factor Improvements – three phase PWM - twelve pulse converters – applications – Numerical problems.

VI. Analysis of step-down and step-up dc to dc converters with resistive and Resistive inductive loads – Switched mode regulators – Analysis of Buck Regulators - Boost regulators – buck and boost regulators – Cuk regulators – Condition for continuous inductor current and capacitor voltage – comparison of regulators –Multi ouput boost converters – advantages – applications – Numerical problems.

VII. Principle of operation – performance parameters – single phase bridge inverter - evaluation of output voltage and current with resistive, inductive and Capacitive loads – Voltage control of single phase inverters – single PWM – Multiple PWM – sinusoidal PWM – modified PWM – phase displacement Control – Advanced modulation techniques for improved performance – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – Advantage – application – numerical problems.

VIII. Three phase inverters – analysis of 180 degree condition for output voltage and current with resistive, inductive loads – analysis of 120 degree Conduction – voltage control of three phase inverters – sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation – Comparison of PWM techniques– harmonic reductions – Current Source Inverter – variable d.c. link inverter – boost inverter – buck and boost inverter - inverter circuit design – advantages –applications – numerical problems.

REFERENCE BOOKS

1. Power Electronics – Mohammed H. Rashid – Pearson Education –Third Edition – First Indian reprint 2004.
2. Power Electronics – Ned Mohan, Tore M. Undeland and William P. Robbins – John Wiley and Sons – Second Edition.

MPE 1.3 ADVANCED POWER SYSTEM ANALYSIS

I. Load flow analysis*:* Review of recent trends in load flow studies, NR method, De-coupled, fast De-coupled and DC load How, Optimal load flow.

II. Power system reliability analysis*:* Basic concepts, Modes of failure, generating system and its performance, Reliability Index-steady state and general reliability expressions.

III. Transient stability studies: swing equation, Transient stability studies using Runge-Kutta method long term transient stability studies.

IV. Dynamic stability*:* Concept of dynamic stability, effect of saliency and saturation on Stability, D'mello-Concordia model, dynamic stability assessment using torque angle loop analysis, Effect of excitation on stability.

V. Power system stabilizer: Introduction, Basic concepts & structure of PSS-

VI. Voltage Stability: Introduction, definition, time frames for voltage instability, mechanism scenarios, relation of voltage stability to rotor angle stability, voltage stability analysis by PV & VQ curves.

REFERENCE BOOKS:
1. Stagg and EI-Abid, Computer methods in power system analysis. McGraw Hill.
2. E. W. Kimbark, Power system Stability Vol-I, Wiley IEEE Press.
3. Byrely and Kimbark, "Stability of large Electric Power System (lEEE Papers).
4. K. R. Padiyar, "Power System Dynamics, Stability and Control", Interline Publishing
5. C.W. Taylor, "Power System Voltage Stability"

MPE 1.4 ELECTIVE I

MPE 1.4.1 ADVANCED DIGITAL SIGNAL PROCESSING

I . Block diagram representation-Equivalent Structures-FIR and IIR digital filter Structures All pass Filters-tunable IIR Digital Filters-IIR tapped cascaded Lattice Structures-FIR cascaded Lattice structures-Parallel-Digital Sine-cosine generator- Computational complexity of digital filter structures.

II. Preliminary considerations-Bilinear transformation method of IIR filter design, design of Low pass highpass-Bandpass, and Band stop- IIR digital filters-Spectral transformations of IIR filters- FIR filter design-based on Windowed Fourier series design of FIR digital filters with least –mean- Square-error-constrained Least-square design of FIR digital filters

III. Computation of the discrete Fourier transform- Number representation-Arithmetic operations-handling of overflow-Tunable digital filters-function approximation.

IV. The Quantization process and errors- Quantization of fixed -point and floating –point Numbers-Analysis of coefficient Quantization effects - Analysis of Arithmetic Round-off errors-Dynamic range scaling-signal- to- noise ratio in Low -order IIR filters-Low-Sensitivity Digital filters-Reduction of Product round-off errors using error feedback-Limit cycles in IIR digital filters- Round-off errors in FFT Algorithms.

V. Estimation of spectra from Finite Duration Observations signals – Non-parametric methods for power spectrum Estimation – parametric method for power spectrum Estimation-Estimation of spectral form-Finite duration observation of signals-Nonparametric methods for power spectrum estimation-Walsh methods-Blackman and torchy method.

REFERENCE BOOKS:
1**.** Digital signal processing-Sanjit K. Mitra-TMH second edition.
2**.** Discrete Time Signal Processing – Alan V. Oppenheim, Ronald W. Shafer -PHI-1996 1st edition-9th reprint.
3**.** Digital Signal Processing principles, algorithms and Applications – John G. Proakis -PHI – 3rd edition-2002.
4**.** Theory and Applications of Digital Signal Proceesing- Lourens R. Rebinarand Bernold.
5. Digital Filter Analysis and Design-Auntonian-TMH.

MPE 1.4.2 TRANSIENT OVERVOLTAGES IN POWER SYSTEMS

I. Transients in electric power systems – Internal and external causes of over voltages-– Lightning strokes – Mathematical model to represent lightning. Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations.

II. Switching transients –double frequency transients – abnormal switching transients – Transients in switching a three phase reactor- three phase capacitor.

III. Voltage distribution in transformer winding – voltage surges-transformers –generators and motors. Transient parameter values for transformers, reactors, generators and transmission lines.

IV. Basic ideas about protection –surge diverters-surge absorbers-protection of lines and stations Modern lighting arrestors. Insulation coordination. Protection of alternators and industrial drive systems.

V. Generation of high AC and DC –impulse voltages, currents- measurement using sphere gaps – peak voltmeters – potential dividers and CRO.

REFERENCE BOOKS:

1. Allen Greenwood, 'Electrical transients in power systems', Wiley Inter science, 1998.
2. Bewley, L.W., 'Traveling waves and transmission systems', Dover publications, New York, 1963
3. Gallaghar, P.J. and Pearmain, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 1982.

MPE 1.4.3 FLEXIBLE AC TRANSMISSION SYSTEMS

I. Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

II. Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

III. Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

IV. Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations.

V. UPFC -Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.

REFERENCE BOOKS:

1. Song, Y.H. and Allan T. John, Flexible ac transmission systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2. Hingorani, L. Gyugyi, 'Concepts and Technology of flexible ac transmission system', IEEE Press New York, 2000 ISBN –078033 4588.
3. IEE Tutorials on 'Flexible ac transmission systems', published in Power Engineering Journal, IEE Press, 1995.

MPE 1.4.4 DISTRIBUTION SYSTEM DESIGN AND CONTROL

I. Distribution system planning & Automation: Introduction, Distribution system planning; factors affecting system planning, present technique, Role of computers in distribution planning, Distribution Automation, local energy control center, Typical control applications.

II. Distribution Substation; Introduction, Load characteristics, substation location, Rating a distribution substation, sub station services area with 'n' primary feeders, Comparison of four and six feeder patterns, derivation of K constant, substation Application curves, present voltage drop formula. Primary and secondary distribution systems: Introduction, feeder types and voltage levels, feeder loading rectangular type development, radial type development application of the A, B, C, D general circuit constants to radial feeders, secondary banking.

III Application of capacitors in distribution systems: Introduction, Power capacitors series, shunt P.F. Correction, economic P-F. Applications of capacitors of installation, types of control, economic justification, practical procedure to determine the best location, mathematical procedure for optimum- allocation,

IV Dynamic behavior of distribution system. Artificial Intelligence methodologies in distribution system operation & control: Introduction, Expert system, knowledge based system, simulated annealing technique for loss minimization and voltage control. Knowledge based methodologies for system reconfiguration and service restoration.

REFERENCE BOOKS:

1. Turan Gonen, "Electric Power Distribution System Engineering", McGraw Hill
2. A. S, Pabla, "Electric Power Distribution System", Second Edition, TMH 3.
3. IEEE transactions of PAS, Power Systems & Power Delivery - Papers on application of AI techniques to power distribution system

MPE 1.4.5 ENERGY SYSTEMS MODELING AND ANALYSIS

I . Modelling overview-levels of analysis, steps in model development, examples of models. Quantitative Techniques: Interpolation-polynomial, Lagrangian. Curve-fitting, regression analysis, solution of transcendental equations. Systems Simulation-information flow diagram.

II. Solution of set of nonlinear algebraic equations, successive substitution, Newton Raphson. Examples of energy systems simulation Optimisation : Objectives/constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimisation- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions.

III. Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate. Case studies of optimisation in Energy systems problems.

IV Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis. Energy- Economy Models: Scenario Generation, Input Output Model.
V. Numerical solution of Differential equations- Overview, Convergence, Accuracy. Transient analysis- application example.

REFERENCE BOOKS:

1. S. S. Rao, Optimisation theory and applications, Wiley Eastern, 1990
2. S. S. Sastry, Introductory methods of numerical analysis, Prentice Hall, 1988
3. P. Meier Energy Systems Analysis for Developing Countries, Springer Verlag, 1984
4. R.de Neufville, Applied Systems Analysis, McGraw Hill, International Edition, 1990

MPE 1.5. ELECTIVE II

MPE 1.5.1 POWER SYSTEM DYNAMICS

I Stability considerations, Dynamic modeling requirements ,voltage & angle stability, equal area criterion, effect of damper winding, AVR's and Governors, critical fault clearing time and angle, numerical Integration techniques.

II Synchronous Machines, park's transformations, flux linkage equations, formulation of normalized equations, state space current model, sub-transient inductances and time constants, simplified models of the synchronous machine, turbine, Generator – steady state equations and phasor diagrams.

III. Dynamics of Synchronous machines, Mechanical relationships, Electrical transient relationships, saturation in Synchronous machines, adjustment of Machine models, parks equation in the operational form. Induction motor equivalent circuits and parameters, free acceleration characteristics, Dynamic performance, changes in load torque, effect of three phase short circuit and unbalanced faults.

IV Transient and Dynamic stability distinction, linear model of unregulated synchronous machine and its oscillation modes, regulated synchronous machine, distribution of power impacts, effects of excitation on stability, supplementary stabilization signals.

REFERENCE BOOKS:

1. Power System Dynamics, K. R Padiyar
2. Power System stability by Prabha Kundur, Tata McGraw Hill publication.
3. Power system control & stability, P.M AndersonGalgotia Publications,
4. Electric energy systems Theory, by O.L Elgerd, Tata McGraw Hill Publications.

MPE 1.5.2 EXTRA HIGH VOLTAGE TRANSMISSION

I. E.H.V. A.C. Transmission line trends and preliminary aspects standard transmission voltages – power handling capacities and line losses – mechanical aspects.

II. 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 conductor lines and multi – conductor lines, Maxwell's coefficient matrix.

III. Line capacitance calculation: capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.

IV. Calculation of electro static field traveling waves due to corona – Audio noise die to corona, its generation, characteristics and limits measurement of audio noise.

V. Surface voltage Gradient on conductors, surface gradient on 2 conductor bundle and consine law, Maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.

VI. Corona: Corona in EHV lines – corona loss formulate – attenuation of traveling waves due to corona – Audio noise due to corona, its generation, characteristics and limits measurement of audio noise.

VII. Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous conductor, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines.

VIII. Static reactive compensating systems: Introduction, SVC schemes, Harmonics injected in to network by TCR, design of filters for suppressing harmonics injected in to the system.

REFERENCE BOOKS:

1. Extra High Voltage AC Transmission Engineering – Rakosh Das Begamudre, Wiley Eastem ltd., New Delhi – 1987.
2. EHV Transmission line reference book – Edision Electric Institute (GEC) 1986.

MPE 1.5.3 OPTIMIZATION TECHNIQUES

I. Linear programming – formulation – Graphical and simplex methods – Big-M method – Two phase method – Dual simplex method – Primal Dual problems.

II. Unconstrained one dimensional optimization techniques -Necessary and sufficient conditions –Unrestricted search methods - Fibonacci and golden section method – Quadratic Interpolation methods, cubic interpolation and direct root methods.

III. Unconstrained n dimensional optimization techniques – direct search methods –Random search –pattern search and Rosen brock's hill claiming method- Descent methods-Steepest descent, conjugate gradient, Quasi Newton methods.

IV. Constrained optimization Techniques- Necessary and sufficient conditions –Equality and inequality constraints-Kuhn-Tucker conditions-Gradient projection method-cutting plane method- penalty function method.

V. Dynamic programming- principle of optimality- recursive equation approach – application to shortest route, cargo-loading, allocation and production schedule problems

REFERENCE BOOKS:

1. Rao, S. S.,'Optimization :Theory and Application' Wiley Eastern Press, 1978.
2. Taha, H. A., Operations Research- An Introduction, Prentice Hall of India.
3. Fox, R. L., 'Optimization methods for Engineering Design', Addition Welsey, 1971.

MPE 1.5.4 UTILIZATION OF SOLAR THERMAL ENERGY

I. Solar Radiation, availability, measurement and estimation; Isotropic and anisotropic models; empirical relations, Solar Collector and thermal storage: steady state and dynamic analysis, Solar pond, Modelling of solar thermal systems and simulations in process design.

II. Design of active systems by f-chart and utilizability methods.

III. Water heating systems: active and passive.

IV. Passive heating and cooling of buildings, Solar distillation, Solar drying

REFERENCE BOOKS:

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
4. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986
5. M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

MPE 1.5.5 DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS

I. Review of numerical methods, Application of numerical methods to solve Transients in DC switched R,L,R-L,R-C and R-L-C circuits, extension to Ac circuits.

II. Modelling of Diode in simulation, Diode with R, R-L, R-C and R-L-C Load with ac supply, Modelling of SCR, TRIAC, IGBTand Power Transistrors in simulation, application of Numerical methods to R-L-C circuits with power Electronic switches, simulation of Gate/Base drive circuits, simulation of snubber circuits.

III. State Space modeling and simulation of linear systems. Introduction to Electrical Machine modeling : Induction, DC & Synchronous machines, simulation of basic electric drives, stability aspects.

IV. Simulation of single phase and Three phase uncontrolled & controlled (SCR) Rectifiers, Converters with self Commutated Devices ,simulation of Power factor Correction schemes, simulation of converter fed DC motor Drives, simulation of Thyristor choppers with voltage, current & load commutation schemes, simulation of Chopper fed Dc motor.

V. Simualtion of Single and Three phase Inverters with Thyristors and self commutated devices, space vector representation, pulse width modulation methods for voltage control, waveform control. Simulation of Inverter fed Induction motor Drives.

REFERENCE BOOKS:

1. Power Electronic Circuits, by ISSA Baterseh, John Wiley
2. Fundamentals of Power electronics, by Robert Erickson, Chapamn & Hall publication

SEMESTER -II

MPE 2.1 ADVANCED POWER SYSTEM PROTECTION

I. General philosophy of protection – Characteristic function of protective relays – basic relay elements and relay terminology – basic construction of static relays – non-critical switching circuits.

II Protective relays –protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection.

III Bus protection. Techniques applicable for line protection –long EHV line protection Backup remote local and Breaker failure.

IV Placement of reactors in power system- Transformer tap changing –Protection of boosters-capacitors in an interconnected power system.

V. Digital signal processing –digital filtering in protection relays- numeric protection –testing. Digital filtering in protection relays – digital data transmission– relay hardware – relay algorithms. Concepts of modern coordinated control system.

REFERENCE BOOKS:

1. Lewis Blackburn, J., 'Protective Relaying – Principles and Applications', Marcel Dekkar, INC, New York, 1987.
2. The Electricity Training Association, 'Power System Protection Vol1-4', The IEE, U.K., 1995.
3. Stanley, H. Horowitz (ED), 'Protective relaying for power systems II', IEEE Press, 1980.
4. Protective Relaying Theory and applications by Elmore Walter A CBS Publishers.

MPE 2.2 POWER ELECTRONICS CONTROL OF DRIVES

I. Introduction to motor drives-Torque production-Equivalent circuit analysis, speed torque characteristics with variable voltage operation, variable frequency operation, constant v/f operation, variable stator current operation, induction motor characteristics in constant torque and field weakening regions.

II. Scalar control, voltage fed inverter control, open lop volts/hertz control, speed control slip regulation, speed control with torque and flux control, current controlled voltage fed inverter drive, current fed inverter control, independent current and frequency control, speed and flux control in current fed inverter drive, volts/Hz control of current fed inverter drive, efficiency optimization control by flux program

III. Slip power recovery drives, static Kramer drive, phasor diagram, torque expression, speed control of Kramer drive, static Scheribus drive, modes of operations

IV. Principles of vector control, vector control methods, direct methods of vector control, indirect methods of vector control, adaptive control principles, self tuning regulator, model reference control

V. Synchronous motor and it's characteristics, control strategies, constant torque angle control, unity power factor control ,constant flux linkage control.

VI. Controllers, flux weakening operations, maximum speed, direct flux weakening algorithm, constant torque mode controller, flux weakening controller, indirect flux weakening, maximum permissible torque, speed control scheme, implementation strategy, speed controller design, Direct torque control (DTC)

VII. Chopper controlled DC motor drives, principle of operation of the chopper, four quadrant chopper circuit, chopper for inversion, chopper with other power devices, model of the chopper, steady state analysis of the chopper controlled DC motor drives, rating of the device, pulsating torque.

REFERENCE BOOKS:

1 Electric Motor Drives Modelling Analysis and Control, R KRISHNAN, Pearson publications.
2 Power Electronics Control of AC Motors, J M D Murphy and F G Turnbull, Pergamon press London.
3 Power Electronics and variable frequency Drives, B K Bose, Standard publications.
4 Power Electronic Circuits, Devices and applications, M H Rashid, Prentice Hall of India publications.
5 Power Electronics and Motor Control, Shepard, Hulley and Liang, Cambridge University press.

MPE 2.3 ENERGY AUDITING, CONSERVATION AND MANAGEMENT

I. Objective: Understanding, analysis and application of electrical energy management-measurement and accounting techniques-consumption patterns- conservation methods-application in industrial cases.

II. System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods-specific energy analysis-Minimum energy paths-consumption models-Case study.

III. Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors. Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study

IV. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance. case study; Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load scheduling-case study;Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study.

V. Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study; Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage. Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- softwares-EMS

REFERENCE BOOKS:

1 Giovanni Petrecca, Industrial Energy Management: Principles and Applications, The Kluwer international series -207, (1999)

2. Anthony J. Pansini, Kenneth D. Smalling, Guide to Electric Load Management, Pennwell Pub; (1998)
3. Turner, Wayne C., Energy Management Handbook, Lilburn, The Fairmont Press, 2001
4. Albert Thumann, Handbook of Energy Audits, Fairmont Pr; 5th edition (1998)
5. Albert Thumann, P.W, Plant Engineers and Managers Guide to Energy Conservation. - Seventh Edition-TWI Press Inc, Terre Haute.

MPE 2.4 ELECTIVE III

MPE 2.4.1 HIGH VOLTAGE D.C. TRANSMISSION

I. H.V.D.C. Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter Configuration.

II. Static Power Converters: 3-pulse, 6-pulse and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers.

III. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

IV. Control of HVDC Converters and systems: constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, DC power flow control.

V. Interaction between HV AC and DC systems – Voltage interaction, Harmonic instability problems and DC power modulation.

VI. Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

VII. Transient over voltages in HVDC systems: Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

REFERENCE BOOKS:

1. E.W. Kimbark : Direct current Transmission, Wiely Inter Science –NewYork.
2. J. Arillaga : H. V. D. C. Transmission Peter Peregrinus ltd., London UK 1983
3. K. R. Padiyar: H. V. Direct current Transmission, Wiely Eastern Ltd., New Delhi – 1992.
4. E. Uhlman: Power Transmission by Direct Current, Springer Verlag, Berlin Helberg – 1985.

MPE 2.4.2 POWER QUALITY

I. Introduction of the Power Quality (PQ) problem, Terms used in PQ: Sags, Swells, Surges, Harmonics, Interruptions. Assessing PQ; Remedies: Customer side of meter, utility side of the meter. Power Quality Data: Data collection, Data analysis, Database structure, Creating PQ databases, Processing PQ data.

II. Voltage sag characteristics; methodology for computation of voltage sag magnitude and occurrence; accuracy of sag analysis; duration and frequency of sags. Effect of transformer connections, effect of pre-fault voltage, simple examples. Voltage dip problems. Fast assessment methods for voltage sags in distribution systems.

III. Adjustable speed drive (ASD) systems and applications, sources of power system harmonics, mitigation of harmonics. Characterization of voltage sags experienced by three-phase ASD Systems: Types of sags and phase – angle jumps. Effects of momentary voltage dip on the operation of induction and synchronous motors. Voltage sag coordination for reliable plant operation.

IV. Harmonic analysis of industrial customers; technical barriers in ASDs. Methods of evaluation of harmonic levels in industrial distribution systems. Harmonic effects on transformers. Impact of distribution system capacitor banks on PQ. Guidelines for limiting voltage harmonics.

V. General plant description, monitoring strategy, equipment selection and testing. Design philosophy of filters to reduce harmonic distortion. Power conditioners. Voltage flicker measurement and analysis System.

VI. Industry standards and general guidelines. Global quality standards: IEEE standards framework for quality.

REFERENCE BOOKS:

1. Recent Technical Papers Published in IEEE on ‘Power Quality’.
2. Power Quality by C. Sankaran, YesDee Publishing
3. Understanding Power quality problems by Bollen M. J. Standard Publishers and Distributors.
4. Handbook of power quality by Angelo Baggini John Wiley publication.

MPE 2.4.3 POWER SYSTEM PLANNING AND RELIABILITY

I. Objectives of planning – Long and short term planning. Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting –– total forecasting – annual and monthly peak demand forecasting.

II. Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique. Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.

III. Transmission system reliability model analysis- average interruption rate – LOLP method – frequency and duration method.

IV. Two plant single load system – two plant two load system –load forecasting uncertainly interconnections benefits.

V. Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents.

REFERENCE BOOKS:

1. Sullivan, R.L., ‘Power System Planning’, Heber Hill, 1977.
2. Roy Billington, `Power System Reliability Evaluation’, Gordan & Breach Scain Publishers, 1970.
3. Dhillan, B.S., ‘Power System Reliability, Safety and Management’, An Arbor Sam, 1981.

MPE 2.4.4 ECONOMIC OPERATION OF POWER SYSTEMS

I. Introduction: Different states of power systems, energy control centers, power systems control problems, steady state & transient security of power systems, security monitoring, SCADA systems, Automatic generation and voltage control.

II. Power System Security Introduction, Factors affecting system security, power system contingency analysis, and detection of network problems. Network Sensitivity methods, calculation of network sensitivity factor, connecting generator dispatch by sensitivity methods, contingency ranking.

III. Control of voltage and reactive_ Power: Introduction, Generation and absorption of reactive power, relation between voltage, power and reactive power at a node-single machine infinity bus system, methods of voltage control-voltage stability, voltage collapse.

IV. Power System Optimization: Optimal system operation with thermal plants, incremental production costs for steam power plants, analytical form of generation costs of thermal power plants constraints in economic operation flow chart. Transmission loss equation for B Co-efficient, unit commitment: statement of the problem, constraints, spinning reserve.

V. Loss Co-efficient : Definitions and Computation of loss co-efficient incremental transmission of transmission loss, loss of co-efficient using Y Bus, Sparse matrix techniques use of load flow jacobian for economic dispatch- flow chart -AGC -AGL - use of AGE for economic dispatch, block diagram, block- merit order scheduling.

REFERENCE BOOKS:

1. P. S. R. Murthy, "Power system operation and control", TMH
2. Stevenson, 'Power system analysis" , -III Edition", McGraw Hill
3. Alien Wood, "Power Generation Operation and Control".
4. Elegard, "Electrical energy systems, TMH
5. Hawary, "Economic operation of power systems",

MPE 2.4.5 ECONOMICS & PLANNING OF ENERGY SYSTEMS

I. System economics:- Basic concepts. National accounting framework. Criteria for Economic growth. Model types & philosophy. Production functions. Input –output economics, macroeconomic growth models.

II. Econometric Models, policy options & budgetary implications, some illustrations of Econometric research for identifying demand functions, supply functions, cost functions, production functions, utility functions & Engel curves. Dynamic models of Economy & simple Theory of business fluctuations. Multiple linear & nonlinear regression analysis, energy per unit monetary value of consumer needs & services, Energy Efficiency, Cost benefit risk analysis.

III. Environmental repercussions & the economic structure. Conflict between Energy consumption & pollution. System design & quantitative economic policy with particular reference to Energy. Econometry in context of multiple objectives, conflicting goals & decisions under uncertainty.

REFERENCE BOOKS:
1. Stoft, Steven " Power System Economics – Designing Markets for Electricity", IEEE Press/ Wiley-Interscience, 2002
2. Rothwell and Gomez " Electricity Economics – Regulation and Deregulation", IEEE Press/ Wiley-Interscience, 2003
3. Shahidepour, Yamin,Li "Market Operations in Electric Power Systems", IEEE Press/ Wiley-Interscience, 2003

MPE 2.5 ELECTIVE-IV

MPE 2.5.1 SPECIAL ELECTRICAL MACHINES

I. Synchronous Reluctance Motors: Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics.

II. SWITCHED RELUCTANCE MOTORS Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control Microprocessor based controller.

III. PERMANENT MAGNET SYNCHRONOUS MOTORS Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

IV. PERMANENT MAGNET BRUSHLESS DC MOTORS Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller.

V. STEPPING MOTORS Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

<u>REFERENCE BOOKS:</u>
1. Miller, T.J.E. "Brushless permanent magnet and reluctance motor drives", Clarendon Press, Oxford, 1989.
2. Kenjo, T, "Stepping motors and their microprocessor control ", Clarendon Press, Oxford, 1989.
3. Kenjo, T and Naganori, S "Permanent Magnet and brushless DC motors", Clarendon Press, Oxford, 1989.
4. B. K. Bose, "Modern Power Electronics & AC drives".
5. R. Krishnan, " Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

MPE 2.5.2 DESIGN AND DEVELOPMENT OF POWER MODULES

I. Design and development of various configurations of power modules using SCRs, IGBTs, power transistors and power MOSFETs. Practical converter design considerations- Snubber design, gate and base drive circuits, heat sink design, design of magnetic components.

II. DC to DC converters of various configurations using SCRs, IGBTs, power transistors and power MOSFETs.

III. DC to AC converters of various configurations using SCRs, IGBTs, power transistors and power MOSFETs.

IV. AC to AC converters of various configurations using SCRs, IGBTs, power transistors and power MOSFETs.

V. Practical implementation of control techniques for voltage control, speed control and harmonic minimization.

REFERENCE BOOKS:

1. Ned Mohan, Undeland and Robbin, 'Power Electronics: converters, Application and design', John Wileyand sons.Inc, Newyork, 1995.
2. M.H. Rashid, 'Power Electronics Handbook', Elseiver Press, 2003.
3. John D. Lenk ,'Simplified Design of Switching Power Supplies', Butterworth-Heinemann,1995.

MPE 2.5.3 POWER SYSTEM INSTRUMENTATION

I. Measurement of large currents and voltages, current and voltage transformers, design equations and operational characteristics, error compensation schemes.

II. Protective CTs and PTs, overload and transient performance, standard specification of instrument transformers.

III. DC current transformers, measurement of power and energy, torque equation of induction type energy meter, parasitic torque's and their minimization, IS specifications, analog and digital KVA meters.

IV. Tele-metering, remote terminal units, data acquisition systems, tri-vector meters, event and disturbance recorders.

REFERENCE BOOKS:

1. Cooper Helfrick, ``Electrical Instrumentation and Measuring Techniques", Prentice Hall India, 1986
2. D. C. Nakra and K. K. Chowdhry, ``Instrumentation, Measurement, and Analysis", Tata McGraw Hill Publishing Co., 1984. Selected topics from IEEE, AIEE and CIGRE Journals.

MPE 2.5.4 ANN APPLICATION IN POWER SYSTEM ENGINEERING

I. Models of a Neuron; Structure of a NN; Learning rules; Learning Paradigms; Single layer and multi layered perception; Kohenon self organizing Networks; Hop fields Networks; the boltzman machines. Applications to Power System operation and Control; Fault detection and location; voltage stability assessment and Enhancement; economic load dispatch and unit commitment; reactive power control.

II. Introduction to ANN technology – principles and promises– perceptron – representation– linear separability – learning – training algorithm – the Back-propagation network – the generalized delta rule –practical consideration – BPN applications.

III Hospfield nets – Cauchy training – simulated annealing– the Boltzmann machine – associative memory –bi-directional associative memory – application.

IV. CPN building blocks – CPN data processing – An image classification example, SOM data processing–application of SOMs.

V. ART network description – ART 1 – ART 2 – application – the formal avalanche – architectures of spatiotemporal networks – the sequential competitive avalanche field – Applications of STNS.

VI. Applications to Power System operation and Control; electric circuit Analysis , Load Scheduling , Load Forecasting , Unit Commitment. Fault detection and location; voltage stability assessment and Enhancement; economic load dispatch and unit commitment; reactive power control.

REFERENCE BOOKS:

1. Simon Hayldn, "Neural Networks-A Comprehensive Foundation", Prentice Hall Inc., 1999.
2. B. Yegnanarayana, "Artificial Neural Networks", Prentice Hall India, 1999.
3. J. M. Zurada, "Introduction to Artificial Neural Systems", Jaico, 1994,
4. John Hetrz, Anders Krogh, Richard G Palmer, "Introduction to the Theory of Neural Computation", Addison" Wesly, 1990, Selected topics from IEEE, AIEE & CIGRE Journals.

MPE 2.5.5 WIND ENERGY CONVERSION SYSTEMS

I. Wind machine types, classification, parameters.

II. Wind, its structure, statistics, measurements, data presentation, power in the wind.

III. Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics, Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics.

IV. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower.

V. Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static - dynamic - fatigue analysis, yawed operation and tower shadow, WECS control system, requirements and strategies.

VI. Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO).

VII. Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters.

VII. Testing of WECS. Noise. Miscellaneous topics.

REFERENCE BOOKS

1. Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
2. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
3. Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.

SEMESTER III

MPE 3.1 DISTRIBUTION AUTOMATION

I. Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software.

II. DA capabilities, Automation system computer facilities, management processes, Information management, system reliability management, system efficiency management, voltage management, Load management.

III. DA communication requirements, Communication reliability, Cost effectiveness, Data rate requirements, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow.

IV. Communication systems used in DA :Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave satellite. fiber optics, Hybrid Communication systems, Communication systems used in field tests.

V. Technical Benefits: DA benefit categories, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings, Operational savings, improved operation, Function benefits, Potential benefits for functions, function shared benefits, Guide lines for formulation of estimating equations.

VI. Parameters required, economic impact areas, Resources for determining benefits impact on distribution system, integration of benefits into economic evaluation. Economic Evaluation Methods :Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives.

VII. Economic comparison of alternate plans, Classification of expenses and capital expenditures, Comparison of revenue requirements of alternative plans, Book Life and Continuing plant analysis, Year by year revenue requirement analysis, short term analysis, end of study adjustment, Break even analysis, Sensitivity analysis computational aids.

REFERENCE BOOKS:

1. IEEE Tutorial Course, "Distribution Automation"
2. IEEE Working Group on "Distribution Automation"

MPE 3.2 ELECTIVE V

MPE 3.2.1 COMPUTER AIDED DESIGN OF ELECTRICAL APPARATUS

I. Conventional design procedures – Limitations – Need for field analysis based design.

II. Electromagnetic Field Equations – Magnetic Vector/Scalar potential – Electrical vector /Scalar potential – Stored energy in field problems – Inductance- Development of torque/force- Laplace and Poisson's Equations – Energy functional - Principle of energy conversion.

III. Mathematical models – Differential/Integral equations – Finite Difference method – Finite element method – Energy minimization – Variational method- 2D field problems – Discretisation – Shape functions – Stiffness matrix – Solution techniques.

IV. Elements of a CAD System –Pre-processing – Modelling – Meshing – Material properties- Boundary Conditions – Setting up solution – Post processing.

V. DESIGN APPLICATIONS Design of Solenoid Actuator – Induction Motor – Insulators – Power transformer

.

REFERENCE BOOKS:

1. S. J Salon, “Finite Element Analysis of Electrical Machines.” Kluwer Academic Publishers, London, 1995.
2. S. R. H. Hoole, Computer – Aided, Analysis and Design of Electromagnetic Devices, Elsevier, New York, Amsterdam, London, 1989.
3. P. P. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983.
4. D. A. Lowther and P. P Silvester, Computer Aided Design in Magnetics, Springer verlag, New York, 1986.

MPE 3.2.2 EMBEDDED CONTROL OF ELECTRICAL DRIVES

I. P89C66x MICROCONTROLLER: Introduction – Timers 0 and 1, Timers 2 – External interrupt – Interrupt priority –Programmable count array – pulse width modulation – watch dog timer – universal asynchronous receiver transmitter – inter integrated circuit – project applications.

II. PIC MICROCONTROLLER AND ARM: CPU Architecture – Instruction set – Interrupts – Timers – Memory – I/O port expansion– I^2C bus for peripheral chip access – A/D converter – UART - ARM architecture –ARM organization and implementation, The ARM instruction set, the thumb instruction.

III. PIC 16C7X MICROCONTROLLER Architecture – memory organization – addressing modes – instruction set – programming techniques – simple operation.

IV. PERIPHERAL OF PIC 16C7X MICROCONTROLLER: Timers – interrupts – I/O ports – I^2C bus for peripheral chip access – A/D converter – VART.

V. MICROCONTROLLERS AND DSP APPLICATIONS: Introduction – dedicated hardware system versus microcontroller control – application areas and functions of microcontroller and DSP in drive technology – control of electric drives using microcontroller and DSP – control system design of microcontroller based variable speed drives – applications in textile mills, steel rolling mills, cranes and hoist drives, cement mills, sugar mills, machine tools, coal mills, paper mills, centrifugal pumps, turbo compressors.

REFERENCE BOOKS:

1. ‘Design with PIC Microcontrollers,’ John B. Peatman Pearson Education, Asia 2004
2. ‘The M68HC11 Microcontroller Applications in control,by Michael Khevi Instrumentation and communication’, Prentice Hall, New Jersey, 1997.
3. ‘Design with Microcontrollers’, John B.Peatman MCGraw Hill

MPE 3.2.3 RESTRUCTURED POWER SYSTEMS

I. Restructuring of Electricity Supply Industry: Power systems operation - old vs new, Key issues associated with the restructuring of ESIs, International experiences.

II. Economic Operation of Power Systems: Economic load dispatch (ELD), Unit commitment (UC), optimal power flow (OPF), OPF in system design and operation. Electricity Markets: Models of competition, Bilateral trading, Electricity pools, Spot market, Settlement process. Power System Controls: Load frequency control, Generator voltage control.

III. System Security and Ancillary Services (AS) Management: Balancing issues, Network issues, System restoration, AS provision, FACTS controllers in AS provision, Co-optimization of AS and energy.

IV. Transmission Pricing and Congestion Management: Electric power wheeling, Transmission open access, Pricing of electric power transmission, Congestion management techniques, FACTS in congestion management.

REFERENCE BOOKS:

1. O.L. Elgerd, Electric Energy Systems Theory: An Introduction, Second Edition, TMH Edition, (1996)
2. L. L. Lai, Power System Restructuring and Deregulation: Trading, Performance and Information Technology, Wiley, (2001)
3. A.J. Wood and B.F. Wollenberg, *Power Generation Operation and Control*, Second Edition, Wiley India Edition, (2003)
4. K. Bhattacharya, M.H.J. Bollen and J.E. Daaler, "*Operaiton of Restructured Power System*", Kluwer Power Electronics and Power Systems Series, (2001)

MPE 3.2.4 ENERGY RESOURCES, ECONOMICS & ENVIRONMENT

I. Overview of World Energy Scenario – Dis-aggregation by end-use, by supply Fossil Fuel Reserves - Estimates, Duration Overview of India's Energy Scenario - Dis-aggregation by end-use, by supply, reserves Country Energy Balance Construction - Examples Trends in energy use patterns, energy and development linkage.

II. Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation, Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis

III. Environmental Impacts of energy use - Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, measurement and controls; sources of emissions, effect of operating and design parameters on emission, control methods, Exhaust emission test, procedures, standards and legislation; environmental audits; Emission factors and inventories Global Warming, CO_2 Emissions, Impacts, Mitigation Sustainability, Externalities, Future Energy Systems.

REFERENCE BOOKS:

1. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2000.
2. AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.

3. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald Global energy perspectives, Cambridge University Press, 1998
4. Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984

MPE 3.2.5 POWER FROM RENEWABLES & ENVIRONMENTAL ASPECTS

I. Renewable Electricity and key elements, Hydropower & its constraints, Environmental impacts of coal based power generation, wind Energy.

II. Technology and Economics, Resources, systems & regional strategies, solar thermal power, photovoltaic technology, Biomass power, Ocean and power, special cost estimates, Dual fuel cycles.

III. Global climate change, CO_2 reduction potential of Renewable Energy, social considerations.

REFERENCE BOOKS:

1. Fowler, J. M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984
2. Wind electrical systems by S. N. Bhadra and S. Banerjee, Oxford University Press

MPE 1.6 POWER ENGINEERING LAB-I

1) Use of software or using MATLAB conduct a power flow study on a given power system network using
a) Gauss Seidal method b) Newton Raphson method c) Fast Decoupled method
2) Develop a program to conduct contingency analysis on a given power system network
3) Develop a program to solve Swing equation
4) Single phase fully controlled converter with inductive load
5) Case studies on Economics of Renewable Energy Systems
6) Simulation of single phase full converter using RL and E load.
7) Simulation of three phase full converter using RL and E load.
8) Simulation of single phase AC voltage controller using RL load.
9) High voltage testing-I
10) High voltage testing-II

MPE 2.6 POWER ENGINEERING LAB-II

1) Four quadrant chopper drive for DC motor control with speed measurement and closed loop control
2) Three phase input thyristorised drive for DC motor with closed loop control.
3) Induction motor speed control using Cycloconverters
4) Develop a Simulink model for a single area load frequency control problem and perform the simulation
5) Develop a Simulink model for a two area load frequency control problem and perform the simulation
6) Vector control of three phase induction motor.
7) Speed control of three phase induction motor.
8) Case studies on Energy Audit of Energy Efficient Lighting
9) Case studies on Energy Audit of Energy Efficient Machines
10) Simulation of resonant pulse commutation circuit
11) Simulation of three phase inverter with PWM controller.
12) Energy Audit case studies of a Process Industry