Biju Patnaik University of Technology, Orissa

Course for M.Tech. Syllabus

(1st Semester, Power System Engineering)

M.Tech (Power System Engineering)

Sem – I

Professional Core	:	EEPC101	Power System Analysis
		EEPC102	Power Apparatus and Systems
		EEPC103	EHVAC Transmission.
Electives	:	EEPE101	Advanced Power Electronics
			OR
		EEPE102	Protection & Digital Relaying
		EEPE103	Optimization Techniques
			OR
		EEPE104	Power Quality.
Sessional	:	EEPR101	Power System Lab – I
Seminar	:	EEPT101	Pre Thesis Work related Seminar

Sem – II

Professional Core	:	EEPC201	Power System Transients.
		EEPC202	Power System Dynamics
Electives	:	EL- 3 (Any One of the following)	
		EEPE201	HVDC Transmission & Facts.
		EEPE202	Power System Management
		EEPE203	Distribution System Engineering
		EL- 4 (Any One of the following)	
		EEPE204	Advanced Control Systems
		EEPE205	Advanced Digital Signal Processing
		EEPE206	Embedded System.
		EL- 5 (Any One of the following)	
		EEPE207	Power System Reliability
		EEPE208	Nonconventional Electrical Energy
		EEPE209	Computer Aided Power System Protection.
Sessional	:	EEPR201	Power System Lab – II
Seminar	:	EEPT201	Pre Thesis Work related Seminar.
Comp. Viva Voce	:	EECV201	Viva Voce- 1

Sem – III

Open Electives	:	OE	a) Soft Computing Application.
			OR
			b) Project Management
			OR
			c) Energy Management
			OR
			b) Project Management Process Control & Instrumentation
Thesis-Part-I	:	TH – I	

Sem- IV

EEPT401	Thesis-Part-II	:	TH – II
EECV401	Seminar	:	Seminar-3
EECV402	Comp. Viva Voce	:	Viva Voce- 2

Power System Analysis

Module- I

Automatic Generation and Voltage Control:

Turbine & Generator- Load frequency Scheme, Steady state & dynamic analysis in frequency domain for single & two area system, Economic dispatch Control, Automatic Voltage Control. Power flow Analysis- NR and Fast Decoupled methods.

Module- II

Optimal System Operation:

Generation allocation problem formulation, Loss Coefficients, Optimal load flow solution, Hydrothermal Coordination, constraints in Unit- commitment, Unit commitment solution methods.

Module- III

Modeling of Transmission lines & transformers with off-nominal taps.

Sparse matrise technique for large- Scale system problems- Gaues elimination & bi-factorization method. Algorithm for short circuit studies, Z Bus Fomulation, Unsymmetrical fault analysis using symmetrical components.

Books Recommended:

1. *Stagg G.W., Eabiad A.H. " Computer methods in Power system analysis." Mc Graw Hill, 1968.*
2. *Nagrath & Kothari, "Modern Power System Analysis"*
3. *Elaerd O.Z, " Electrical Energy System Theory- An*

POWER APPARATUS AND SYSTEMS

Module-I **(12 Hrs)**

Synchronous Machines: The basis of General Theory and Generalized Equation of A.C machines, Equation in terms of phases variable park's transformation, Various reference frames, Derivation of two-axis equation, Torque equation, Field and damper windings, Equivalent circuits, Operational impedances and frequency response loci, Modified equation with more accurate coupling between field and damper windings.

Selected topics on prime mover and energy supply systems: Governors for hydraulic and steam turbines, Transient droop, speed governing system.

Module-II **(12 Hrs)**

Synchronous Generator short circuit and system faults: Symmetrical short circuit of unloaded generator, Analysis of short circuit oscillograms, short circuit of loaded synchronous generator, Unsymmetrical short of synchronous generator, system fault calculation, Sudden load changes, Equivalent circuit under transient condition, Constant flux linkage theorem, Simplified phasor diagram for transient changes.

Selected topics on excitation systems: Modeling of excitation system components, exciter (D.C and A.C), Amplifier, Stabilizing circuit

Module-III **(12 Hrs)**

Induction machines: Generator equation of the induction motor (equation), Application of equation in primary and secondary reference frames and complex form of equation, Short circuit and fault current due to the induction motor, fault calculation.

Transformers: Transient phenomena in transformer and transformer protection: General characteristics of over voltage and current inrush, Transient over voltage characteristics tics, Ferro resonant over voltage, protection against surges and insulation co-ordination.

BOOKS RECOMMENDED :

1. *The Generalized theory of electrical machines (Chapters: 1,2,34,5,8 and 11 by B.Adkins and R.H. Hiiley.*
2. *Principle, Operation and Design of power Transformer By S.B Vasciitnsky.*
3. *The J & P transformer Book (Chapter: 22&23) By S. Austen Stigant and A.C Franklin.*
4. *Power System Stability & Control (Chapters: 8&9) By P.Kundur, McGraw Hill-1994.*

EHVAC Transmissions

Module- I (10 hrs)

Introduction to EHV Transmission Comparison of AC and DC Transmission Systems. Parameters of EHV Lines:- Resistance of conductors, bundle conductors, Inductance of EHV Line configurations line capacitance, Sequence Inductance and capacitance, Line parameters for modes of propagation, resistance and Inductance of Ground returns.

Module- II (10 hrs)

Voltage Gradient of conductors:- Field of sphere gap, field of line charges and their properties. Charge – potential relations for multi-conductor lines surface voltage gradient and conductors without and with ground wires consideration, gradient factors, Distribution of voltage gradient on sub-conductors of bundle.

Module- III (10 hrs)

Corona effects- I : Power loss and Audible Noise Corona loss, Charge- Voltage diagram. Attenuation of traveling waves Audible.

Noise: Generation, Characteristics and its limitation, Measurement, meters, 1-phase and 3-phase AN levels, Day-Night equivalent Noise level.

Power frequency voltage control and over-voltage:- Generalised constants, Cascade connection of components-shunt and series compensation. Sub-synchronous Resonance in series- capacitor compensated lines, Static Reactive compensating systems.

Module – IV (10 hrs)

Over voltage in EHV systems caused by switching operations:-

Origin of over voltage and their types, short circuit current and circuit breaker. Recovery voltage and the circuit breaker, Over voltage caused by interruption of inductive current, Interruption of capacitive currents, Ferro resonance over voltage, calculation of switching surges single phase equivalents, distributed parameter line energized by source, generalized equations for single phase representation, Generalised equation of three phase systems, inverse Fourier transform for the general case, Reduction of switching surges on EHV systems, Experimental and calculated results of switching surge studies.

Books:-

1. *Begamudre R.D., "Extra High Voltage A.C. Transmission" Mc Graw Hill 1968.*

Advanced Power Electronics

Model-I

1-Φ and 3-ф Controlled rectifiers-Average output voltages and currents for R-L. load performance parameters of rectifier 1- ф and 3- ф converter. DC-DC converters: Buck, Boost, Buck-boost and Cuk converters, linear power supplies. Switch mode DC Power supplies, Fly back converter, Forward converter, push pull converter , half bridge and full bridge converter.

Module-II

Basic concepts of switch mode inverter, pulse width modulated switching scheme , unipolar and bipolar Switching scheme, 1-ф inverters, push pull inverters, 3-ф inverters, PWM in 3-ф voltage source inverters. Reduction of Harmonies , square-wave pulse switching, programmed Harmonic elimination switching.

Module-III

Resonant pulse Converters: Classification of resonant Converters, series Resonant Inverter: Series Resonant inverters with unidirectional switches, series resonant inverters with bi-directional switches. Parallel Resonant Inverters, Zero current switching resonant converters, zero voltage switching resonant converters.

Books for Reference

1. Power electronics, Circuits, devices. Application by M.H.Rashid (PHI)
2. Power electronics, converters ., applications and Design N.Mohan undeland and Robbins John wily and sons inc.
3. Modern Power electronics and AC Drives by B.K .Bose.

PROTECTION AND DEGITAL RELAYING

Module-I

Protection Schemes and Characteristics: Primary and back up protection , current transformers for protection , potential transformer, review of electromagnetic relays static relays , over current relays time current characteristic, current setting time setting, directional relay, static over current relays.

Distance protection: impedance, reactance, mho, angle impedance relays. Input quantities for various types of distance relays, effect of arc resistance on the performance of distance relays, selection of distance relays. MHO relay with blinders, quadrilateral relay , elliptical relay. Restricted mho, impedance directional, reactance relays, swiveling characteristics.

Module-II

Compensation Schemes: Compensation for correct distance measurement , reduction of measuring units switched schemes. Pilot relaying schemes. Wire pilot protection , circulating current scheme, balanced voltage scheme, transley scheme, carrier current protection , phase comparison carrier current protection, carrier aided distance protection.

Module-III

Digital Relaying: Digital relaying algorithms, differential equation technique, discrete Fourier transform technique, walsh-hadamard transform technique, rationalized harr transform technique, removal of dc offset.

Microprocessor based protective relays: over current , directional, impedance, reactance relays. Generalized mathematical expressions for distance relays, mho and offset mho relays, quadrilateral relay, microprocessor implementation of digital distance relaying algorithms.

Text book

1. Power system protection and switchgear by Badri ram and vishwkrama, TMH publication New Delhi 1995.
2. power system protection by Madhava Rao TMH

Reference Books

1. Power system by Ravindra Nath and chandar PHI.

Optimization Techniques

Module-I

Optimization Fundamentals:

Definition , classification of optimization problems, Unconstrained and constrained optimization, optimality conditions.

Linear Programming:

Simplex Method, Duality, Sensitivity methods.

Module-II

Nonlinear Programming:

Powel's method, steepest descent method, conjugates gradient method, Newton's Method GRG method, Sequential quadratic programming, Penalty function method, Augmented Lagrange multiplier method.

Dynamic Programming and Integer Programming

Interior point methods

Karmakar's algorithm , Dual affine, Primal affine , Barrie algorithm.

Module-III

Simulated annealing , Evolutionary Programming , Genetic algorithm and Genetic Engineering.

Finite Element Based Optimization.

Reference Books

1. Ashok D.belegundu and Chrandrapatla T. R " Optimization Concept and Application in Engineering " Prentice Hall, 1999.
2. Rao S.S " Engineering Optimization"
3. Gill , Murray and Wright ," Practical Optimization"
4. James A. Memoh." Electic Power System Application of optimization."
5. song Y. , "Modern Optimization Techniques in power System"

POWER QUALITY

Module-I

Introduction: power quality (PQ) problem, Voltage sag, Swell , Surges, Harmonic, over voltages, spikes, Voltage fluctuations, Transients, interruption overview of power quality phenomenon , Remedies to improve power quality, power quality monitoring.

Interruptions: Definition, Difference between failure, outage, causes and origin of interruptions, limits for the interruption frequency, limits for the interruption duration , costs of interruption, overview of Reliability , evaluation to power quality, comparison of observations and reliability evaluation.

Module-II

Voltage Sag: Characterization of voltage sag , definition, causes of voltage sag , voltage sag magnitude , monitoring, theoretical calculation of voltage sag magnitude , voltage sag calculation in non-radial systems, meshed systems, voltage sag duration.

PQ considerations in Industrial Power Systems: voltage sag effects, equipment behavior of power electronic loads, induction motors , synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC drives, Adjustable speed DC drive and its operation, mitigation methods of DC drives.

Module-III

Mitigation of Interruptions and Voltage Sags: Overview of mitigation methods- form fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods . System equipment interface- voltage source converter , series voltage controller , shunt controller , combined shunt and series controller.

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards , PQ surveys.

Reference Book:

1. " Understanding Power Quality Problems" by Math H J Bollen, IEEE Press.
2. Electrical power quality –R C Dugan, M.F,M Granghar, H.W.Beaty-TMH.

POWER SYSTEMS TRANSIENTS

Module-I (15 Hours)

INTRODUCTION TO FAST TRANSIENTS:

Origin and nature of power system Transients, traveling waves on transmission system, the line equation, the shape attenuation and distortion of waves, reflection of traveling waves , successive reflections, traveling waves on multi conductor systems, transition points on multi conductor circuits.

LIGHTNING : Charge formation , mechanism of lightning stroke. Mathematical model of lightning stroke.

Module-II (15Hours)

THEORY OF GROUNDS WIRES :Direct stoke to a tower, effect of reflection up and down the tower , the counterpoise.

SWITCHING SURGES :

Normal frequency effects, high charging currents, cancellation waves, recovery voltage, restricting phenomena. Protection of transmission systems against surge.

HIGH FREQUENCY OSCILLATIONS AND TERMINAL TRANSIENTS OF TRANSFORMER

Module-III (15 Hours)

INSULATION COORDINATION:

Insulation coordination procedures (IEC) for high voltage systems: Design criteria, classification of overvoltages, insulation design for switching, lightning and temporary overvoltages, pollution, application of arresters for protection of lines and stations, statistical methods of insulation coordination, risk of failure, test prescriptions. Insulation coordination procedures (IEC) for low voltage systems: representative overvoltages, selection of clearance and creepage distances, macro and micro environments, testing techniques, transient (switching and lightning) voltage surge suppression in industrial and commercial electrical installations, protection of electronic devices.

REFERENCES

1.Allan Greenwood , Electrical Transients in power Systems , Wiley Iterscience, 1991
2.Lou Van Der Sluis, Transients in power Systems , John Wiley & Sons Ltd, 2001
3.R Rudenterg, Transient Performance of Electric power systems, Phenomenon in Lumped Networks, MGH, 1950
4.R Rudenterg, Electric Stroke waves in power systems, Harvard University press, Cambridge, Massachusetts, 1968
5.Transmission Line Reference Book, EPRI, USA, 1982

Power System Dynamics

Module-I (15 Hours)

Power System Stability Problems: Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.

Small Signal Stability: State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, small signal stability of a single machine infinite bus system,

Module-II (15 Hours)

Studies of parametric effect: effect of loading, effect of K_A, effect of type of load, Hopf bifurcation, Electromechanical oscillating modes, Stability improvement by power system stabilizers. Design of power system stabilizers.

Large Perturbation Stability: Transient stability: Time domain simulations and direct stability analysis techniques (extended equal area criterion)

Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modeling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multimachine PEBS.

Module-III (15 Hours)

Sub Synchronous Oscillations: Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters, Sub Synchronous Resonance (SSR): characteristics of series capacitor – compensated transmission systems, self – excitation due to induction generator effect, torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems.

Voltage stability, System oscillations

References:

1.Prabha. Kundur, *Power system stability and control*, Tata McGraw-Hill, 1994

2.P. Sauer and M. Pai, *Power system dynamics and stability*, Prentice Hall, 1998.

HVDC & FACTS

Module-I (15hours)

Introduction: Comparison of AC-DC Transmission, Description and application of HVDC transmission, DC System components and their functions

Analysis of HVDC Converters: Pulse number, Converter configuration, Analysis of Graetz circuit, Bridge characteristics, 12 pulse converter

HVDC Control: Principles of DC Link control-Converter control characteristics- System control, Firing angle control- Current and extinction angle control, DC link power control, Reactive power control and VAR sources, MTDC system- types- control and protection- DC circuit breakers

Module-II. (15hours)

FACTS Concept and General System:

Transmission interconnections, Flow of power in AC system, Power flow and dynamic stability considerations of a transmission interconnection, Relative importance of controllable parameters, Basic types of FACTS controllers, Benefits from FACTS Technology, In-perspective: HVDC or FACTS

Module-III (15hours)

Compensators: Objective of series and shunt compensation, SVC and STATCOM, GCSC, TSSC, TCSC, and SSSC, UPFC, IPFC, Generalized and Multifunctional FACTS Controllers

Books Recommended

1.Padiyar K.R., “HVDC Power Transmission System”, Wiely Eastern PVT Limited
2.Kimbark, “Direct Current transmission”, Vol.1, John Wielly, New York, 1971
3.Understanding FACTS: Cocepts and Technology of Flexible AC Transmission Systems. By N. G. Hingorani and L. Gyugi, Standard Publisher Distributors, IEEE Press, Delhi
4.Flexible AC Transmission Systems. By J. Arillage

POWER SYSTEM MANAGEMENT

Module-I (15 Hours)

Load characteristics and load forecast

Basic definitions- load definitions, load factor definitions, diversity principle in distribution systems, Load Forecast- factors affecting load forecasting methods, small areas load forecasting, spatial load forecasting methods, simulation, trending and mixed load forecasting methods

Basics of Power System Economics & Short-term Operation Planning of Power System, Load curves and load duration curves, Economic load dispatch- concept of marginal cost and Kuhn-Tucker's condition of optimum in power dispatch, participation factors

Module-II (15 Hours)

Classical method to calculate loss coefficients, Loss coefficient calculation using Y-Bus, Loss coefficients using sensitivity factors, Transmission loss coefficients, Transmission loss formula

Power Pools & Electricity Markets

Inter-area transactions, multi-area power interchanges, Energy brokerage systems, Market design and auction mechanism, Pool versus bilateral markets and price formation, Role of independent generators and system operator

Module-III (15 Hours)

Power Sector Financing

Time value of money, utility economic evaluation, Capacity planning issues and methods- Levelizing and levelized bus-bar analysis, Screening curve analysis, Horizon-year generation additions analysis, Capacity planning in competitive environment

References

1. A. J. Wood and B. F. Wollenberg, *Power generation, operation and control,* Wiley-Interscience, 2nd Edition, 1996.
2. H. G. Stoll, *Least-cost electric utility planning*, Wiley-Interscience, 1989.
3. K. Bhattacharya, M. H. J. Bollen and J. E. Daalder, *Operation of restructured power systems,* Kluwer Academic Publishers, USA, 2001.

DISTRIBUTION SYSTEM ENGINEERING

Module-I **(15 Hours)**

Distribution system planning

Short term planning, Long term planning, Dynamic planning, Sub-transmission and substation design, Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves

Module-II **(15 Hours)**

Distributed Generation

Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts

DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources, Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection

Module-III **(15 Hours)**

Primary and secondary system design considerations

Primary circuit configurations, Primary feeder loading, secondary networks design

Economic design of secondaries, Unbalance loads and voltage considerations

Distribution system performance and operation

Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems

Text Books

1.Anthony J. Pansini “Electrical Distribution Engineering”, CRC Press.
2.H Lee Willis, “Distributed Power Generation Planning and Evaluation”, CRC Press.
3.James A Momoh, “Electric Power Distribution Automation Protection And Control” CRC Press
4.James J. Burke “Power distribution engineering: fundamentals and applications”, CRC Press.
T. Gonen, *Electric Power Distribution System Engineering*, McGraw-Hill, 1986, ISBN 0-07-023707

ADVANCED CONTROL SYSTEMS

Module-I : **(14 Hours)**

Digital Control **:** State Space Representations of Discrete Time Systems, Solution of Discrete Time State Equations, Discretization of Continuous Time State Equations. Controllability and observability of Linear Time Invariant Discrete Data Systems, Pole Placement, Deadbeat response, Digital Simulation.

Module -II : **(15 Hours)**

Optimal Control : Performance Indices, Quadratic Optimal Regulator / Control Problems, Formulation of Algebraic Riccati Equation (ARE) for continuous and discret time systems. Solution of Quadratic Optimal Control Problem using Lograng Multiplies for continuous and discrete-time systems. Evaluation of the minimum performance Index, Optimal Observer, The Linear Quadratic Gaussia (LQG) Problem, Introduction to H_∞ Control.

Module - III : **(14 Hours)**

Non linear Systems **:** The Aizerman and Kalman Conjectures : Popov's stability criterion, the generalized circle criteria, simplified circle criteria. Simple variable structure systems, sliding mode control, feedback linearization, Model reference adaptive control, (MRAC), Self Tuning Regulator (STR).

Fuzzy Logic Control **:** Fuzzy sets and crispsets, Fuzzy Relations and composition of Fuzzy Relations, Introduction to Fuzzy Logic Controllers.

Books :

1. Discrete Time Control Systems, by K.Ogata, 2nd edition (2001), Pearson Education publication.
2. Digital Control Systems, by B.C. Kuo, 2nd edition (1992), Oxford University Press.
3. Digital Control and State Variable Methods, by M.Gopal, 3rd edition (2009), Tata Mc. Graw Hill Education Pvt. Ltd.
4. Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).
5. Design of Feedback Control Systems by Raymond T. Stefani, B.Shalia, Clement J. Savant, Jr. Gen H. Hostetter, 4th edition (2002), Oxford University Press.
6. Introduction to Control Engineering (Modeling, Analysis and Design) by Ajit K. Mandal, New Age International (P), Ltd., Publishers (2006).
7. Non Linear Systems, by Hassan K. Khallil, 3rd edition (2002), Prentice Hall, Inc. (Pearson Education), Publications.
8. Control Theory (Multivariable and non linear Methods) by Torkel Glad & Lennart Ljung, Taylor & Francis (2009).

ADVANCED DIGITAL SIGNAL PROCESSING

Module-I: (15 hours)

Discrete time signals, systems and their representations:

Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of continuous time signals- Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z- transform- Properties of different transforms- Linear convolution using DFT- Computation of DFT

Module II: (15 hours)

Digital filter design and realization structures

Design of IIR digital filters from analog filters- Impulse invariance method and Bilinear transformation method- FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations

Module III (15 hours)

Analysis of finite word-length effects

Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters

Statistical signal processing

Linear Signal Models . All pole, All zero and Pole-zero models .Power spectrum estimation- Spectral analysis of deterministic signals . Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation-Optimum FIR and IIR filters.

Texts/ References

1. Sanjit K Mitra, Digital Signal Processing: A computer-based approach ,Tata Mc Grow-Hill edition .1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing, Mc Grow Hill international editions .-2000
3. Alan V . Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997
4. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing(third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997
5. Emmanuel C. Ifeachor, Barrie W. Jervis , Digital Signal Processing-A practical Approach, Addison . Wesley,1993
6. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976

Embeded System

Module-I(15 Hours)

Introduction: An embedded system, Processor in the system, Other hardware units, Software embedded into a systems, exemplary system-in-chip

Devices and Device Drivers : I/O devices, Timer and counting devices, serial communication using the IC, CAN and advance I/O buses between the networked multiple devices. Host system or computer parallel communication between the networked I/O multiple devices using the ISA, PCI, PCI-X and advance buses. Device drivers, Parallel port devices drivers in a system, Serial port device drives in a system, Interrupt servicing (Handling) mechanism.

Module-II(15 Hours)

Software and Programming Concept : Processor selection for an embedded system, memory selection for an embedded system, Embedded programming in C++, Embedded programming in JAVA, Unified modeling language (UML), Multiple processes and application, problem of sharing data by multiple tasks and routines, Inter process communication.

Real time Operating System: Operating system services, I/O subsystem, Network operating system, Real Time and embedded system, Need of well tested and debugged Real Time operating system (RTOS), Introduction to C/OS-II.

Case studies of programming with RTOS : Case study of an embedded system for a smart card

Module-III(15 Hours)

Hardware and Software Co-design : Embedded system project management, Embedded system design and co-design issues in system development process, design cycle in the development phase for an embedded system, Use of software tools for development of an embedded system, Issues in embedded system design.

References:

1...Embedded System Architecture, Programming and Design, Raj Kamal, TMH
2.Hardware Software Codesign of Embedded System, Ralf Niemann, Kulwer Academic
3.Embedded Real time system Programming, Sriram V. Iyer and Pankaj Gupat, TMH

Power system Reliability

Module-I (15Hours)

Generating Capacity Basic Probability Methods: The generation system model, Loss of load indices, Equivalent forced outage rate, Capacity expansion analysis, Scheduled outages, Evaluation methods on period basis, Load forecast uncertainty, Forced outage rate uncertainty, Loss of energy indices.

Generating Capacity Frequency & Duration Method: The generation model, System risk indices.

Module-II (15 Hours)

Interconnected Systems: Probability error method in two interconnected systems, Equivalent assisting unit approach to two interconnected systems, Factors affecting the emergency assistance available through the interconnections, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected system, multi connected system, Frequency & duration approach.

Operating Reserve: General concepts, PJM method, Extension to PJM method, Modified PJM method, Postponable outages, Security function approach, Response risk, Interconnected systems.

Module-III (15 Hours)

Composite Generation & Transmission Systems: Radial configurations, Conditional probability approach, Network configurations, State selection, System & load point indices, Application to practical systems, Data requirements for composite system reliability.

Plant & Station Availability: Generating plant availability, Derated states & auxiliary systems, Allocation & effect of spares, Protection systems, HVDC systems.

Distribution Systems Basic Techniques & Radial Networks: Evaluation techniques, additional interruption indices, Application to radial systems, effect of lateral distributor protection, Effect of disconnects, Effect of protection failures, effect of transferring loads, Probability distributions of reliability indices.

Distribution Systems-Parallel & Meshed Networks: Basic evaluation techniques, Inclusion of busbar failures, Inclusion of scheduled maintenance, Temporary & transient failures, Inclusion of weather effects, Common modes failures, Common mode failures & weather effects, Inclusion of breaker failures.

Text Books

1.Billinton Roy& Allan Ronald “Reliability of Power system”, Pitman Pub. 1984

2.Richard Elect. Brown, “Electric Power Distribution Reliabilty”, CRC Press

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NON CONVENTIONAL ELECTRICAL ENERGY SYSTEMS

MODULE-I (15 HOURS)

Introduction to Non-conventional/Renewable Energy Sources & Technologies. Their Importance for Sustainable Development and Environmental Protection.

SOLAR RADIATIONS: Measurement and Prediction of Solar Radiations; Instruments for Solar Radiation; Characteristics of Solar Spectra including Wavelength Distribution; Radiation Properties and Spectral Characteristics of Materials; Selective Surfaces & Basics of Solar Collectors.

SOLAR THERMAL SYSTEM:Solar Collection Devices; their analysis; Solar Collector Characteristics; Solar Pond; application of solar energy to space heating etc.

MODULE-II (15 HOURS)

BIOMASS:Biomass as an Energy Source; Energy Plantations; Conversion Technologies – Thermal, Chemical and Biological; Photosynthesis, Biogas generation, Classification of Biogas plants.

BIOGAS: Principles of Bioconversion: Types of Bioreactors – Batch, Continuous, Plug-flow, Stirred Tank & Film, Reaction Kinetics, Reactor Design and Analysis, materials-Municipal Refuse, Sewerage, Industrial Wastes, Agricultural Wastes, Animal and Human Wastes; Landfill systems; Properties and Uses of Biogas.

BIOFUELS:

Bioconversion Techniques – Direct Combustion, Pyrolysis, Flash Pyrolysis Fermentation and Gasification; Utilization of Industrial Wastes such as Bagasse; Household and Community Combustion Systems – Improved Cook-stoves; Industrial Biomass Combustion Systems; Gasification; Sizing; Beneficiation of Fuels. Thermodynamics & Kinetics of Gasification; Types of Gasifiers–Downdraft, Updraft, Cross flow, Fluidized. Combustion Characteristics of Biofuels; Utilization in Conventional Engines and or Power Generation including Cogeneration.

Waves: Nature and availability of Energy from waves Onshore & Off-shores: Principles of Wave Converters – Raft, Duck, Oscillating Water Columns, Tapered Channels & Buoys; Energy Conversion & Transmission; Secondary Applications of Waves

MODULE-III (15HOURS)

WIND ENERGY: Basic Principle; Basic components of a WECS, Classification of W.E.C., Their types, Applications of Wind Energy, Environmental aspects, Wind Energy Developments in India.

Tides: Origin & nature of Tides, Tidal Heads & Duration; Principles of Tidal Energy Conversion, Site Selection – Single and Multiple Bay System; Cycles & Load Factors; Regulation and Control of Tidal Power Generato **(Ocean Thermal Energy Conversion):** Temperate & Tropical Oceans; Principles of OTEC Systems; Site Selection; Power Cycles; Selection of Working Fluids; Pumps & Turbines; Heat Exchanger Criteria; Bio-fueling; Secondary Applications such as Fresh Water Production, Maniculture, etc., Power Transmission & System Efficiency.

GEOTHERMAL ENERGY: Name of Geothermal Resources, Location and Potential Assessment, Classification & Characteristics of Geothermal Resources, Chemical & Physical Properties of Geothermal Brines: Control of Scale Deposition, Drilling, Logging & Cementing Operations for Geothermal Wells; Principles of Power Production System & Cycles: Refrigeration, Two-Phase Flow Turbines; Thermal Phase Flow Turbines; Thermal Utilization & Mineral Recovery; Ecological and Safety Considerations.

BOOKS:

1. S.P. Sukhatme - Solar Energy: Principles of thermal Collection and Storage,TMH,New Delhi
2. H.P. Garg and Jai Prakash - Solar Energy: Fundamentals and Applications,TMH
3. Chang - Energy Conversion, Prentice Hall
4. Soo- Direct Energy Conversion, Prentice Hall
5. Bockris and Srinivasan - Fuel Cells, McGraw Hill
6. Duffic and Beckman - Solar Engineering of Thermal Processes, John wiley

Computer Aided POWER SYSTEM PROTECTION

Module-I (15 Hours)

Introduction To Computer Relaying: Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Analog to digital converter, Anti-aliasing filter, Substation computer hierarchy.

Relaying Practices: Introduction to protection systems, Functions of a protection system, Protection of transmission lines, Transformer, reactor & generator protection, Bus protection, Performance of current & voltage transformers.

Module-II (15 Hours)

Mathematical Basis For Protective Relaying Algorithms: Introduction, Fourier series, Other orthogonal expansion, Fourier transform, Use of fourier transform, Discrete fourier transform, Introduction to probability & random processes, Random processes, Kalman filtering.

Transmission Line Relaying: Introduction, Sources of error, relaying as parameter estimation, Beyond parameter estimation, Symmetrical component distance relay, protection of series compensated lines.

Module-III (15 Hours)

Protection Of Transformers, Machines & Buses: Introduction, Power transformer algorithms, Generator protection,, Motor protection, Digital bus protection.

Hardware Organisation In Integarted Systems: The nature of hardware issues, Computers for relaying, The substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary equipment, Redundancy & backup, Servicing, training & maintenance.

System Relaying & Control: Introduction, Measurement of frequency & phase, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurement in dynamic state estimation, Monitoring.

Developments In New Relaying Principles: Introduction, Traveling waves on single-phase lines, Traveling waves on three-phase lines, Traveling waves due to faults, Directional wave relays, Traveling wave distance relay, Differential relaying with phasors, Traveling ` wave differential relays, Adaptive relaying,

Text Book

1.A.G. Phadke and J.S. Thorp, " Computer Relaying for Power Systems", John Wiley and Sons, 1994

Power System Laboratory-II

1. Power System Analysis using ETAP
2. Optimisation of Power System Operation using MATLAB optimization tool box or MATLAB Programming
3. Simulation of Thyristor Converter using PSCAD
4. DATA Acquisition using SCADA System
5. Simulation of Induction Motor drive using PSCAD
6. Economic Load dispatch.
7. Analog to digital Converter interfacing, Interfacing DAC to Microprocessor

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