SRI KRISHNA COLLEGE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

AUTONOMOUS CURRICULUM - 2015 Regulations (CBCS)

TOTAL CREDITS: 75

SEMESTER I

S.No	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Stream
1.	15PMA101	Applied Mathematics for Electrical engineers	3/2/0	4	4	BS
2.	15PPS301	Advanced Power System Analysis	4/0/0	4	4	PC
3.	15PPS302	Power System Operation And Control	4/0/0	4	4	PC
4.	15PPS5xx	Professional Elective I	3/0/0	3	3	PE
5.	15PPS5xx	Professional Elective II	3/0/0	3	3	PE
6.	15PPS5xx	Professional Elective III	3/0/0	3	3	PE
7.	15PPS303	Power system simulation laboratoryI	3/0/0	3	2	PC
Total			**23/2/0**	**24**	**23**	

SEMESTER II

S.No	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Stream
1.	15PPS304	Digital Power System Protection	3/0/0	3	3	PC
2.	15PPS305	Power System Dynamics and Control	4/0/0	4	4	PC
3.	15PPS306	Restructured Power Systems	4/0/0	4	4	PC
4.	15PPS5xx	ProfessionalElective IV	3/0/0	3	3	PE
5.	15PPS5xx	Professional Elective V	3/0/0	3	3	PE
6.	15PPS5xx	Professional Elective VI	3/0/0	3	3	PE
7.	15PPS307	Power system simulation laboratory II	3/0/0	3	2	PC
Total			**23/0/0**	**22**	**22**	

SEMESTER III

S.No	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Stream
1.	15PPS5xx	Professional Elective VII	3/0/0	3	3	PC
2.	15PPS5xx	Professional Elective VIII	3/0/0	3	3	PC
3.	15PPS5xx	Professional Elective IX	3/0/0	3	3	PC
4.	15PPS701	Project work phase –I	0/0/12	12	6	PW
5.	15PPS801	Research Methodology	2/0/0	2	-	MC
Total			**9/0/12**	**23**	**15**	

SEMESTER IV

S.No	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Stream
1	15PPS702	Project work phase –II	0/0/24	24	12	PW
Total			**0/0/24**	**24**	**12**	

Can be completed in any of the semesters from II to III

S.No	Name of the Course			L/T/P	Contact Hours/Wk	Credits
1.	Industrial Practice	Three 1 Credit Course	One 3 Credit Elective Subject	--	--	3

PROFESSIONAL ELECTIVES

Course Code	Course Title	Credit
15PPS501	Electro Magnetic Field Computation And Modeling	3
15PPS502	Analysis Of Electrical Machines	3
15PPS503	Analysis Of Inverters	3
15PPS504	EHV Power Transmission	3
15PPS505	Special Electrical Machines	3
15PPS506	Power Quality Analysis	3
15PPS507	Power System Planning And Reliability	3
15PPS508	Advanced Digital Signal Processing	3
15PPS509	Control System Design	3
15PPS510	Optimal Control And Filtering	3
15PPS511	Advanced Power System Dynamics	3
15PPS512	System Identification And Adaptive Control	3

15PPS513	Industrial Power System Analysis And Design	3
15PPS514	High Voltage Direct Current Transmission	3
15PPS515	Wind Energy Conversion Systems	3
15PPS516	Soft Computing Techniques	3
15PPS517	Power Electronics For Renewable Energy Systems	3
15PPS518	Applications Of MEMS Technology	3
15PPS519	Nano Science And Technology	3
15PPS520	Power Quality	3
15PPS521	Electrical Transients In Power Systems	3
15PPS522	System Theory	3
15PPS523	Flexible AC Transmission Systems	3
15PPS524	Energy Auditing and Management	3
15PPS525	Power System Optimization	3
15PPS526	Power System Planning and Reliability	3
15PPS527	Modern Power Generation Systems	3
15PPS528	Power System Security	3
15PPS529	Control System Software	3
15PPS530	Virtual Instrumentation	3

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PMA101	**APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS**	3	1	0	4

1. Course objectives:

Apply their knowledge in modern industry or teaching, or secure acceptance in high-quality graduate programs in mathematics and other fields such as the field of quantitative/mathematical finance, mathematical computing, statistics and electrical Systems.
To understand the applications of matrix theory.
To understand the standard distribution and its applications.
To calculate the performance measures of the standard queuing models.
To solve ordinary differential equation and partial differential equation numerically.

2. **Course pre-requisites** **:** Numerical Methods
Engineering Mathematics-I

UNIT-I ADVANCED MATRIX THEORY 9
Eigen-values using QR transformations –Generalized eigen vectors –Canonical forms -Canonical basis –Singular value decomposition and applications –Pseudo inverse –Least square approximations.

UNIT-II LINEAR PROGRAMMING 9
Formulation –Graphical Solution –Simplex Method –Two Phase Method –Transportation and Assignment Problems.

UNIT-III ONE DIMENSIONAL RANDOM VARIABLES 9
Random variables –Probability function –moments –moment generating functions and their properties –Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions –Function of a Random variable.

UNIT-IV QUEUING MODELS 9
Markovian models –M/M/1-finite capacity and infinite capacity, M/M/C -finite capacity and infinite capacity -M/G/1 queue (steady state solutions only) –Pollaczek –Khintchine formula –Problems.

UNIT- V COMPUTATIONAL METHODS IN ENGINEERING 9
Boundary value problems for ODE –Finite difference methods –Numerical solution of PDE –Solution of Laplace and Poisson equations –Liebmann's iteration process –Solution of heat conduction equation by Schmidt explicit formula and Crank-Nicolson implicit scheme –Solution of wave equation.

STATE OF ART (Not for Exam)
Applications of Linear Programming problem in Engineering field-Bulk service Queueing models-Shooting method– Rayleigh-Ritz method –Characteristic value problems –Solution using Characteristic polynomial method

Total Hours: 60

3. Course outcomes:

Students apply the concept of matrix theory in the analysis of various circuits.
Students analyze many real life phenomena using Probability concepts.
Students use numerical methods to solve many engineering problems.

REFERENCES:

1. Bronson, R., Schaum's outline of "Matrix operations", 2nd edition, McGraw-Hill, New York, 2011.
2. Taha, H. A., "Operations Research: An Introduction", 7th Edition, Pearson Education Edition, Asia, New Delhi ,2002.
3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye "Probability & Statistics for Engineers & Scientists", 9th Edition, Prentice Hall, 2012.
4. Donald Gross and Carl M. Harris, "Fundamentals of Queueing theory", 4th edition, John Wiley and Sons, New York, 2013.
5. S. Palaniammal, "Probability and Queueing Theory", PHI Learning Pvt. Ltd., 2012.
6. Grewal, B.S., "Numerical methods in Engineering and Science", 10th edition, Khanna Publishers, 2010.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS301	**ADVANCED POWER SYSTEM ANALYSIS**	4	0	0	4

1. ***Course objectives:***

   Understand the operation of the power system in terms of frequency regulation, economic dispatch, and unit commitment.

   Demonstrate load flow concepts and to study system performance under different operating conditions

   Perform fault analysis using symmetrical components and determine fault currents and voltages at various locations in the network.

   Understand the principles of steady-state stability assessment and transient stability assessment in power systems, and perform an analysis of transient stability using the equal area criterion for the one machine and infinite bus system.

   Incorporate short circuit analysis and transient stability analysis into the design of a transmission addition to a power

2. **Course pre-requisites** : Power System

UNIT - I SOLUTION TECHNIQUE **12**

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

UNIT -II POWER FLOW ANALYSIS **12**

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

UNIT - III OPTIMAL POWER FLOW **12**

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

UNIT - IV SHORT CIRCUIT ANALYSIS **12**

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems.

Computer method for fault analysis using ZBUS and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase domain using The venin's equivalent and ZBUS matrix for different faults.

UNIT - V TRANSIENT STABILITY ANALYSIS **12**

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

STATE OF ART (Not for Exam)

Advanced simulation techniques for power system problems

Total Hours : 60

3. ***Course outcomes:***

Students understand the operation of power system and load flow concepts.

Students perform fault analysis and transient stability analysis

REFERENCES:

1. G W Stagg, A.H El. Abiad "Computer Methods in Power System Analysis", McGraw Hill, 1968.
2. P.Kundur, "Power System Stability and Control", McGraw Hill, 1994.
3. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", John Wiley and sons, New York, 1996.
4. W.F.Tinney and W.S.Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug 1973.
5. K.Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96; Book on "Large Sparse Set of Linear Systems" Editor: J.K.Rerd, Academic Press, 1971.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS302	**POWER SYSTEM OPERATION AND CONTROL**	4	0	0	4

1. ***Course objectives:***

To get an overview of system operation and control.

To understand & model Real power-voltage interaction and different methods of control for maintaining voltage profile against varying system load.

To understand & model Reactive power-voltage interaction and different methods of control for maintaining voltage profile against varying system load & model power-frequency dynamics and to design power-frequency controller.

To understand Economic load dispatch

To study modern techniques in computer control of power systems

2. **Course pre-requisites** : Power System

Power System Analysis

UNIT - I LOAD FORECASTING 12

Introduction – Estimation of Average and trend terms – Estimation of periodic components – Estimation of Stochastic components: Time series approach – Auto- Regressive Model, Auto-Regressive Moving – Average Models – Kalman Filtering Approach – On-line techniques for non stationary load prediction.

UNIT -II POWER FLOW ANALYSIS 12

Constraints in unit commitment – Spinning reserve – Thermal unit constraints – Other constraints – Solution using Priority List method, Dynamic programming method - Forward DP approach Lagrangian relaxation method – adjusting .

UNIT - III GENERATION SCHEDULING 12

The Economic dispatch problem – Thermal system dispatching with network losses considered – The Lambda – iteration method – Gradient method of economic dispatch – Economic dispatch with Piecewise Linear cost functions – Transmission system effects – A two generator system – coordination equations – Incremental losses and penalty factors-Hydro Thermal Scheduling using DP.

UNIT - IV CONTROL OF POWER SYSTEMS 12

Review of AGC and reactive power control -System operating states by security control functions – Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) - Energy control center – SCADA system – Functions – monitoring , Data acquisition and controls – EMS system.

UNIT - V STATE ESTIMATION 12

Maximum likelihood Weighted Least Squares Estimation: - Concepts - Matrix formulation - Example for Weighted Least Squares state estimation ; State estimation of an AC network: development of method – Typical results of state estimation on an AC network – State Estimation by Orthogonal Decomposition algorithm – Introduction to Advanced topics : Detection and Identification of Bad Measurements , Estimation of Quantities Not Being Measured , Network Observability and Pseudo – measurements – Application of Power Systems State Estimation.

STATE OF ART (Not for Exam)

Smart grid operation and control.

Total Hours : 60

3. ***Course outcomes:***

   Students understand the basics of power system operation and control and Economic load dispatch.

   Students understand and model real and reactive power-voltage interaction and different methods of control for maintaining voltage profile against varying system load

REFERENCES:

1. O.I.Elgerd, "Electric Energy System Theory - an Introduction", - Tata McGraw Hill, New Delhi – 2002.
2. P.Kundur ; "Power System Stability and Control", EPRI Publications, California , 1994.
3. Allen J.Wood and Bruce.F.Wollenberg, "Power Generation Operation and Control', John Wiley & Sons, New York, 1996.
4. A.K.Mahalanabis, D.P.Kothari. and S.I.Ahson., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd , 1984.G W Stagg, A.H El. Abiad "Computer Methods in Power System Analysis", McGraw Hill, 1968.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS303	**POWER SYSTEM SIMULATION LABORATORY- I**	**0**	**0**	**4**	**2**

1. ***Course objectives:***

To understand the formation of network matrices, basic aspects of steady state analysis, mathematical formulation of load flow problems and basics of problems in economic dispatch.

To become familiar with modelling and power flow analysis, analysis of switching surge,various aspects of transient and small signal stability analysis and contingency analysis.

LIST OF EXPERIMENTS

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

Semester II

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS304	**DIGITAL POWER SYSTEM PROTECTION**	**3**	**0**	**0**	**3**

1. ***Course objectives:***

To understand the basics of numerical relay and its protection.
To design the digital protection scheme of transmission line based upon travelling wave phenemenon
To analyze and rectify faults in synchronous generator and transformer by adopting various protection schemes
To understand the concept of distance and overcurrent relay and its co-ordination.
To develop protection algorithms for short Circuit faults.

2. **Course pre-requisites** **:** Power System Protection and Switch Gear
Electrical Machines

UNIT - I NUMERICAL PROTECTION **9**

Introduction , block diagram of numerical relay, sampling theorem, correlation with a reference wave, Least Error Squared (LES) technique, digital filtering, numerical overcurrent protection.

UNIT -II DIGITAL PROTECTION OF TRANSMISSION LINE **9**

Introduction, Protection scheme of transmission line, distance relays, traveling wave relays, digital protection scheme based upon fundamental signal, hardware design, software design, digital protection of EHV/UHV transmission line based upon traveling wave phenomenon, new relaying scheme using amplitude comparison.

UNIT - III DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR AND POWER TRANSFORMER **9**

Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator. Faults in a transformer, schemes used for transformer protection, digital protection of transformer..

UNIT - IV DISTANCE AND OVERCURRENT RELAY SETTING AND CO-ORDINATION 9

Directional instantaneous IDMT over current relay, directional multizone distance relay, distance relay setting, co-ordination of distance relays, co-ordination of over current relays, computer graphics display, man-machine interface subsystem, integrated operation of national power system, application of computer graphics

UNIT - V PC APPLICATIONS IN SHORT CIRCUIT STUDIES FOR DESIGNING RELAYING SCHEME **9**

Types of faults, assumptions, development of algorithm for Short Circuit studies, PC based integrated software for Short Circuit studies, transformation to component quantities, Short Circuit studies of multiphase systems. Ultra high speed protective relays for high voltage long transmission line.

STATE OF ART (Not for Exam)

Man machine interface subsystem coordination using computer graphics, Integrated operation of national power system and its application.

Total Hours : 45

3. Course outcomes:

Students understand the basics of Numeric relay and its protection
Students design the digital protection scheme of transmission line and analyze faults in synchronous generator and transformer by adopting various protection schemes
Students understand the concepts of relays and its co-ordination and develop protection algorithms for short circuit faults.

REFERENCES:

1. Singh L.P., “Digital Protection, 2nd Edition New Age International (P) Limited, New Delhi, 1997.
2. Paithankar , “Transmission Network Protection”, Marcel & Dekker, New York, 1998.
3. Paithankar and Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, second edition, 2010.
4. Stanley Horowitz, “Protective Relaying for Power System II”, John Wiley & sons, 2008.
5. Rao T.S.M., “Digital Relay / Numerical relays”, Tata McGraw Hill, New Delhi, 2005.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS305	**POWER SYSTEM DYNAMICS AND CONTROL**	4	0	0	4

1. *Course objectives:*

Calculate fault currents in simple circuits with paper and pencil.
Write computer programs that can calculate fault currents in larger systems.
Solve basic relay coordination problems
Solve dynamics problems using Park transform stability models.

2. Course pre-requisites : Power System Analysis
Electrical Machines

UNIT - I SYNCHRONOUS MACHINE MODELLING 12

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: Lad-reciprocal per unit system and that from power-invariant form of Park's transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : Neglect of stator p terms and speed variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical.

UNIT -II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 12

Excitation System Requirements; Elements of an Excitation System; Types of Excitation System;Control and protective functions;IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modelling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function

UNIT - III SMALL- SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 12

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-space representation, stability of dynamic system, Linearisation, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT - IV SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS 12

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT - V ENHANCEMENT OF SMALL SIGNAL STABILITY 12

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta –P-Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain – Phase lead compensation – Stabilizing signal washout stabilizer gain – Stabilizer limits

STATE OF ART (Not for Exam)

Application of wavelets in power system stability problems, Numerical Integration methods for transient stability.

Total Hours : 60

3. Course outcomes:

Students calculate fault currents in simple circuits and write programs to calculate fault currents in larger systems.

Students solve basic relay co-ordination problems and dynamics problems.

REFERENCES:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power system
3. Studies", IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973. On Turbine-
4. Governor Model.
5. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS306	**RESTRUCTURED POWER SYSTEMS**	4	0	0	4

1. Course objectives:

Understand different restructuring models and key issues in electric utilities restructuring.

Explain electric utility, power exchange, scheduling, market operations, and transmission management and transmission system security in California Markets.

Understand OASIS structure, functionality and architecture, transfer capability issues and transmission services.

Understand the essence of electric energy trading. Understand volatility, risk and forecasting in electricity pricing

2. Course pre-requisites : Power System Analysis
Power System Operation and Control

UNIT I OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES RESTRUCTURING 12

Restructuring Models: PoolCo Model, Bilateral Contracts Model, Hybrid Model - Independent System Operator (ISO): The Role of ISO - Power Exchange(PX): Market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic Markets - Market Power - Stranded costs - Transmission Pricing: Contract Path Method, The MW-Mile Method - Congestion Pricing: Congestion Pricing Methods, Transmission Rights - Management of Inter-Zonal/Intra Zonal Congestion: Solution procedure, Formulation of Inter-Zonal Congestion Sub problem, Formulation of Intra-Zonal Congestion Sub problem.

UNIT II ELECTRIC UTILITY MARKETS IN THE UNITED STATES 12

California Markets: ISO, Generation, Power Exchange, Scheduling Co-ordinator, UDCs, Retailers and Customers, Day-ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts(TCCs) - New York Market: Market operations - PJM interconnection - Ercot ISO - New England ISO - Midwest ISO: MISO's Functions, Transmission Management, Transmission System Security, Congestion Management, Ancillary Services Coordination, Maintenance Schedule Coordination - Summary of functions of U.S. ISOs.

UNIT III OASIS: OPEN ACCESS SAME-TIME INFORMATION SYSTEM 12

FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Implementation of OASIS Phases: Phase 1, Phase 1-A, Phase 2 - Posting of information: Types of information available on OASIS, Information requirement of OASIS, Users of OASIS - Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation - Transmission Services - Methodologies to Calculate ATC - Experiences with OASIS in some Restructuring Models: PJM OASIS, ERCOT OASIS.

UNIT IV ELECTRIC ENERGY TRADING 12

Essence of Electric Energy Trading - Energy Trading Framework: The Qualifying factors - Derivative Instruments of Energy Trading: Forward Contracts, Futures Contracts, Options, Swaps, Applications of Derivatives in Electric Energy Trading - PortFolio Management: Effect of Positions on Risk Management - Energy Trading Hubs - Brokers in Electricity Trading - Green Power Trading.

UNIT V ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING 12

Electricity Price Volatility: Factors in Volatility, Measuring Volatility - Electricity Price Indexes: Case Study for Volatility of Prices in California, Basis Risk - Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves - Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves – Short-term Price Forecasting: Factors Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors, Practical Data Study.

STATE OF ART (Not for Exam)

Optimization control techniques in Restructured power system, Bidding strategies in Indian restructured power system.

Total Hours : 60

3. Course outcomes:

Students understand different restructuring models and functionality and architecture of OASIS structure.

Students understand the importance of electric energy trading and electricity pricing.

REFERENCES:

1. G.W.Stagg, A.H.El.Abiad "Computer Methods in Power System Analysis", McGraw Hill, 1968.
2. M.K. Jain, N.D.Rao, G.J.Berg, "Improved Area Interchange Control Method for use with any Numerical Technique", I.E.E.E. P.E.S Winter Power Meeting 1974.
3. J.P.Britton, "Improved Area Interchange Control for Newton's method Load Flows", Paper 69 TP 124-PWR presented at IEEE Winter Power Meeting, NewYork, Jan 26-31, 1969.
4. W.F.Tinney and W.S.Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug 1973.

5. K.Zollenkopf, “Bi-Factorization : Basic Computational Algorithm and Programming Techniques ; pp:75-96 ; Book on “Large Sparse Set of Linear Systems” Editor: J.K.Rerd, Academic Press, 1971.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS307	**POWER SYSTEM SIMULATION LABORATORY-II**	0	0	4	2

1. *Course objectives:*

To understand Small-signal stability analysis of single machine and multi-machine configuration, Load flow analysis and Transient analysis of two-bus system with STATCOM.
To calculate available transfer capability using an existing load flow program and compute harmonic indices generated by a rectifier feeding a R-L load.

LIST OF EXPERIMENTS

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

Semester III

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS801	**RESEARCH METHODOLOGY**	2	0	0	0

1. *Course objectives:*

To impart scientific, statistical and analytical knowledge for carrying out research work effectively.
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UNIT I INTRODUCTION TO RESEARCH 9
The hallmarks of scientific research – Building blocks of science in research – Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing.

UNIT II EXPERIMENTAL DESIGN 9
Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and

attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures.

UNIT III DATA COLLECTION METHODS 9

Interviewing, Questionnaires, etc. Secondary sources of data collection. Guidelines for Questionnaire Design – Electronic Questionnaire Design and Surveys. Special Data Sources: Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data-Collection Methods and their utility. Sampling Techniques – Probabilistic and non-probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size.

UNIT IV MULTIVARIATE STATISTICAL TECHNIQUES 9

Data Analysis – Factor Analysis – Cluster Analysis – Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical (SPSS) Software Package in Research.

UNIT V RESEARCH REPORT 9

Purpose of the written report – Concept of audience – Basics of written reports. Integral parts of a report – Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report – Experimental, Results and Discussion – Recommendations and Implementation section – Conclusions and Scope for future work.

REFERENCES:

1. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2000
2. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.
3. C.R.Kothari, Research Methodology, Wishva Prakashan, New Delhi, 2001.
4. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore, 2002.
5. G.W.Ticehurst and A.J.Veal, Business Research Methods, Longman, 1999.
6. Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.

ELECTIVES

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS501	**ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING**	3	0	0	3

1. Course objectives:

To understand the Concepts of electrostatics, electrical potential, energy density and their applications.
To solve the Field Equations.
To apply the Design concepts in various fields
To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.

2. Course pre-requisites : Field Theory

UNIT I INTRODUCTION **9**

Review of basic field theory – electric and magnetic fields – Maxwell's equations – Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation.

UNIT II SOLUTION OF FIELD EQUATIONS I **9**

Limitations of the conventional design procedure, need for the field analysis based design, problem definition , solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III SOLUTION OF FIELD EQUATIONS II **9**

Finite element method (FEM) – Differential/ integral functions – Variational method – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problem.

UNIT IV FIELD COMPUTATION FOR BASIC CONFIGURATIONS **9**

Computation of electric and magnetic field intensities– Capacitance and Inductance – Force, Torque, Energy for basic configurations.

UNIT V DESIGN APPLICATIONS **9**

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

STATE OF ART (Not for Exam)

3D Field computation-Parallel Computation, Visualization Methods-Virtual Reality Systems

Total Hours : 45

3. Course outcomes:

Students understand the concepts of electrostatics, electrical potential, energy density and their applications.

Students solve field equations and apply design concepts in various fields.

Explains finite element method in solving electromagnetic field problems.

REFERENCES:

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", Springer-Verlage, 1992.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. S.J Salon, "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS502	**ANALYSIS OF ELECTRICAL MACHINES**	**3**	**0**	**0**	**3**

1. Course objectives:

To understand the principle of Electromagnetic Energy Conversion.

To explain the concept of Reference Frame Theory.

To write voltage and Torque equations of various machines.
To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

2. Course pre-requisites : Electrical Machines

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9
General expression of stored magnetic energy, co-energy and force/ torque – example using single and doubly excited system –Calculation of air gap mmf and per phase machine inductance using physical machine data.

UNIT II REFERENCE FRAME THEORY 9
Static and rotating reference frames – transformation of variables – reference frames – transformation between reference frames – transformation of a balanced set –balanced steady state phasor and voltage equations – variables observed from several frames of reference.

UNIT III DC MACHINES 9
Voltage and toque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

UNIT IV INDUCTION MACHINES 9
Voltage and torque equations – transformation for rotor circuits – voltage and toque equations in reference frame variables – analysis of steady state operation – free acceleration characteristics – dynamic performance for load and torque variations – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES 9
Voltage and Torque Equation – voltage Equation in arbitrary reference frame and rotor reference frame – Park equations - rotor angle and angle between rotor – steady state analysis – dynamic performances for torque variations- dynamic performance for three phase fault – transient stability limit – critical clearing time – computer simulation.

STATE OF ART (Not for Exam)
A novel concept of Multiphase and multi-motor vector controlled drive system,Modelling of 9 phase synchronous machines.

Total Hours : 45

3. Course outcomes:
Students understand the concepts of electromagnetic energy conversion and explains the concept of reference frame theory
Students write voltage and torque equation of various machines
Students analyze the steady state and dynamic state operation of three-phase induction machines and three phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

REFERENCES:

1. Paul C.Krause, OlegWasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.

2. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” , Prentice Hall of India, 2002
3. Samuel Seely, “ Electromechanical Energy Conversion”, Tata McGraw Hill Publishing Company
4. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “ Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS503	**ANALYSIS OF INVERTERS**	3	0	0	3

1. ***Course objectives:***

To know the Principle of operation of Single Phase & Three Phase Inverters.
To analyze the operation of current source inverters.
To explain the concept of multilevel inverters.
To know the practical applications of inverters.
To understand the concept of resonant inverter.

2. **Course pre-requisites** **:** Power Electronics

UNIT I SINGLE PHASE INVERTERS 9

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

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS 9

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

UNIT III CURRENT SOURCE INVERTERS 9

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

UNIT IV MULTILEVEL INVERTERS 9

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

UNIT V RESONANT INVERTERS 9

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

STATE OF ART (Not for Exam)

Green power UPS, Interleaved flyback micro inverter.

Total Hours : 45

3. ***Course outcomes:***

Students understand the operation of single phase and three phase inverters
Students analyze the operation of current source inverters.
Students explain the concept of multilevel inverters.
Students understand the concept of resonant inverter and knows the practical application of inverters

REFERENCES:

1. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
4. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
5. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
6. Ned Mohan,Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Inc,Newyork,1995.
7. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS504	**EHV POWER TRANSMISSION**	**3**	**0**	**0**	**3**

1. Course objectives:

Understand different configurations of EHV and UHV lines, power handling capacity, costs of transmission lines and equipment and mechanical considerations in line performance.

Calculate parameters like resistance, inductance and capacitance of multi conductor lines.

Derive charge-potential relations and understand voltage gradient for conductors.

Understand power and audible losses and their characteristics.

Explain electrostatic fields of EHV lines and their effect on humans, animals, and plants

2. Course pre-requisites **:** Transmission and Distribution

UNIT I INTRODUCTION 9

Standard transmission voltages – different configurations of EHV and UHV lines – average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

UNIT II CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS 9

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

UNIT IV CORONA EFFECTS 9

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

UNIT V ELECTROSTATIC FIELD OF EHV LINES 9

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

STATE OF ART (Not for Exam)

EHV cables and their characteristics, Design of EHV lines based on steady state transient limits.

Total Hours : 45

3. Course outcomes:

Students understand the different configurations of EHV and UHV lines, power handling capacity, costs of transmission lines and equipment and mechanical considerations in line performance.

Students calculate parameters like resistance, inductance and capacitance of multi conductor lines and derive charge-potential relations

Students understand voltage gradient for conductors, power, audible losses and their characteristics.

Students explain electrostatic fields of EHV lines and their effect on humans, animals, and plants

REFERENCES:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, Second Edition, New Age International Pvt. Ltd., 1990.
2. Power Engineer’s Handbook, Revised and Enlarged 6th Edition, TNEB Engineers’ Association, October 2002.
3. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com).

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS505	**SPECIAL ELECTRICAL MACHINES**	3	0	0	3

1. Course objectives:

Understand the constructional features, operating principles and characteristics of synchronous reluctance motors.

Understand the constructional features, principle of operation, modes of excitation, characteristics and torque production in Variable Reluctance (VR) stepping motor.

Explain the constructional features, operating principles and characteristics of switched reluctance motors.

Explain principle of operation, basic expressions, and characteristics of permanent magnet synchronous motor.

Differentiate mechanical and electronic commutators, understand the operation of permanent magnet brushless DC motors and plot its speed torque characteristics.

2. Course pre-requisites : Electrical Machines

UNIT I SYNCHRONOUS RELUCTANCE MOTORS 9

Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics – Linear induction machines.

UNIT II STEPPING MOTORS 9

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.

UNIT III SWITCHED RELUTANCE MOTORS 9

Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTORS 9

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

UNIT V PERMANENT MAGNET BRUSHLESS DC MOTOR 9

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.

STATE OF ART (Not for Exam)

Role of Special electrical machines in defense and rural areas, challenging issues for Special electrical machines

Total Hours : 45

3. Course outcomes:

Students understand the constructional features and operating principles of synchronous reluctance motor and variable reluctance stepping motor

Students understand the constructional features and operating principles of switched reluctance motor and permanent magnet synchronous motor

Students differentiate mechanical and electronic commutators, understand the operation and characteristics of permanent magnet brushless DC motors

REFERENCES:

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. Kenjo, T. Power Electronics for the microprocessor Age, 1989.
5. B.K. Bose, “Modern Power Electronics & AC drives”, IEEE press, 1998.
6. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS506	**POWER QUALITY ANALYSIS**	3	0	0	3

1. Course objectives:

To know the characterization of Electrical power Quality and Power Quality Standards.

To understand the principle of Three phase static AC/DC converters.

To study various transformation techniques & their computation
To understand custom power devices and its applications.

2. Course pre-requisites : Power Quality

UNIT I INTRODUCTION 9

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

UNIT II NON-LINEAR LOADS 9

Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

UNIT III MEASUREMENT AND ANALYSIS METHODS 9

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

UNIT IV ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT V POWER QUALITY IMPROVEMENT 9

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

STATE OF ART (Not for Exam)

Power Quality Analysis Methods-Stock well transform, Window function

Total Hours : 45

3. Course outcomes:

Students know the characterization of Electrical power Quality and Power Quality Standards
Students understand the principle of Three phase static AC/DC converters
Students explains various transformation techniques & their computation
Students understand custom power devices and its applications.

REFERENCES:

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
3. R.C. Duggan,et al., "Electric Power Systems Quality" Mc Graw Hill Publications.
4. A.J. Arrillga, "Power system harmonics", John Wiely and sons, 2003.

5. Derek A. Paice, “Power electronic converter harmonics”, IEEE Press, 1995.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS507	**POWER SYSTEM PLANNING AND RELIABILITY**	**3**	**0**	**0**	**3**

1. ***Course objectives:***

Understand the Objectives of load forecasting, Load growth patterns, Weather sensitive load forecasting, determination of annual forecasting and use of AI in load forecasting.
Analyze generation system reliability.
Analyze transmission system reliability.
Understand expansion planning in integrate transmission system.
Understand distribution system planning, protection and coordination of protective devices.

2. **Course pre-requisites** : Power System Analysis
Transmission and Distribution
Power system Operation and Control

UNIT I LOAD FORECASTING 9
Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

UNIT II GENERATION SYSTEM RELIABILITY ANALYSIS 9
Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of iso and interconnected generation systems.

UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9
Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV EXPANSION PLANNING 9
Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT V DISTRIBUTION SYSTEM PLANNING OVERVIEW 9
Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

STATE OF ART (Not for Exam)
Static Security Analysis at control centers, Innovative tools for planning and reliability

Total Hours : 45

3. ***Course outcomes:***

Students understand the objectives of load forecasting, Load growth patterns, Weather sensitive load forecasting and determination of annual forecasting
Students analyze transmission and generation system reliability

Students understand distribution system planning, protection and coordination of protective devices

REFERENCES:

1. Proceeding of work shop on energy systems planning & manufacturing CI.
2. R.L .Sullivan, “ Power System Planning”, Tata Mc Graw Hill, 1997.
3. Roy Billinton, “Power System Reliability Evaluation” ,Gordon and Breach Science Publishers,1970.
4. Turan Gonen, Electric power distribution system Engineering ‘McGraw Hill,1986

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS508	**ADVANCED DIGITAL SIGNAL PROCESSING**	3	0	0	3

1. Course objectives:

To study various transformation techniques & their computation
To study various Estimation & Prediction Techniques.
To understand the architecture of DSP and its applications.
To implement the concept of DSP on VLSI

2. **Course pre-requisites** **:** Digital Signal processing

UNIT I INTRODUCTION 9
Mathematical description of change of sampling rate – Interpolation and Decimation, Filter implementation for sampling rate conversion – direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals

UNIT II ESTIMATION AND PREDICTION TECHNIQUES 9
Discrete Random Processes – Ensemble averages, Stationary processes, Autocorrelation and Auto covariance matrices. Parseval’s Theorem, Wiener-Khintchine Relation – Power Spectral Density**.** AR, MA, ARMA model based spectral estimation. Parameter Estimation, Linear prediction – Forward and backward predictions, Least mean squared error criterion – Wiener filter for filtering and prediction, Discrete Kalman filter.

UNIT III DIGITAL SIGNAL PROCESSOR 9
Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.

UNIT IV APPLICATION OF DSP 9
Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

UNIT V VLSI IMPLEMENTATION 9
Basics on DSP sytem architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

STATE OF ART (Not for Exam)
Sigma-delta converters, Multi rate signal processing for intentional Aliasing.

Total Hours : 45

3. Course outcomes:

Students study various transformation techniques, their computation and various estimation and prediction techniques.
Students understand the architecture of DSP
Students implement the concept of DSP on VLSI

REFERENCES:

1. Bernard Widrow, Samuel D. Stearns, "Adaptive Signal Processing", Pearson Education, third edition, 2004.
2. Dionitris G. Manolakis, Vinay K. Ingle, Stepen M. Kogon,"Statistical & Adaptive signal processing, spectral estimation, signal modeling, Adaptive filtering & Array processing", McGraw-Hill International edition 2000.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", John Wiley and Sons, Inc.,
4. John G. Proaks, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education 2002.
5. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing", TMH,2000.
6. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx", Thomson India, 2004.
7. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999,New York.
8. Ashok Ambardar,"Digital Signal Processing: A Modern Introduction",Thomson India edition, 2007.
9. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999,New York

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS509	**CONTROL SYSTEM DESIGN**	3	0	0	3

1. Course objectives:

To study the three ways of designing compensation for a control system.
To design a system using root locus & Bode plot.
To understand Sampling theory concepts.
To Formulate Optimal control problems.
To solve State Estimation problem

2. **Course pre-requisites** **:** Control System

UNIT I CONVENTIONAL DESIGN METHODS 9
Design specifications- PID controllers and compensators- Root locus based design- Bode based design- Design examples

UNIT II DESIGN IN DISCRETE DOMAIN 9
Sample and Hold-Digital equivalents-Impulse and step invariant transformations-Methods of discretisation-Effect of sampling- Direct discrete design – discrete root locus Design examples

UNIT III OPTIMAL CONTROL 9
Formation of optimal control problems-results of Calculus of variations- Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati's equation
State and output Regulator problems-Design examples

UNIT IV DISCRETE STATE VARIABLE DESIGN 9
Discrete pole placement- state and output feedback-estimated state feedback-discrete optimal control-dynamic programming-Design examples

UNIT V STATE ESTIMATION **9**

State Estimation Problem -State estimation- Luenberger's observer-noise characteristics- Kalman-Bucy filter-Separation Theorem-Controller Design-Wiener filter-Design examples.

STATE OF ART (Not for Exam)

Robust control-H-infinity control, Control system design for Robot control.

Total Hours : 45

3. Course outcomes:

Students study the methods of designing compensation for control system. Students understand the architecture of DSP

Students design systems using root locus and bode plot.

Students understand sampling theory concepts

Students formulate optimal control problems and solve state estimation problems

REFERENCES:

1. M. Gopal "Modern control system Theory" New Age International, 2005.
2. Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004.
3. G. F. Franklin, J. D. Powell and A. E. Naeini "Feedback Control of Dynamic Systems", PHI (Pearson), 2002.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado "Control system Design", PHI (Pearson), 2003.
5. G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.
6. B.D.O. Anderson and J.B. Moore., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
7. Loan D. Landau, Gianluca Zito," Digital Control Systems, Design, Identification and Implementation", Springer, 2006.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS510	**OPTIMAL CONTROL AND FILTERING**	3	0	0	3

1. Course objectives:

Formulate optimal control problem and understand the necessary conditions for optimal control.

Solve linear optimal regulator problem and apply dynamic programming in continuous and discrete systems.

Explain different numerical techniques for optimal control

Understand filtering, estimation, noise smoothing and prediction.

Explain different properties of Kalman filters and extended kalman filter

2. **Course pre-requisites** **:** Power System Operation and Control

UNIT I INTRODUCTION **9**

Statement of optimal control problem – Problem formulation and forms of optimal Control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

UNIT II LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING **9**

Linear optimal regulator problem – Matrix Riccatti equation and solution method – Choice of weighting matrices – Steady state properties of optimal regulator – Linear tracking problem – LQG problem –

Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

UNIT III NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9
Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods

UNIT IV FILTERING AND ESTIMATION 9
Filtering – Linear system and estimation – System noise smoothing and prediction –Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

UNIT V KALMAN FILTER AND PROPERTIES 9
Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

STATE OF ART (Not for Exam)
Linear optimal missile guidance using LQR, Dynamic programming and adaptive critic design.

Total Hours : 45

3. Course outcomes:

Students formulate optimal control problem and understand the necessary conditions for optimal control.
Students solve linear optimal regulator problem and explain different numerical techniques for optimal control
Students understand filtering, estimation, noise smoothing and prediction.
Students explain properties of Kalman filters and extended kalman filter

REFERENCES:

1. Kirk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS511	**ADVANCED POWER SYSTEM DYNAMICS**	3	0	0	3

1. Course objectives:

To know various numerical Integration methods.
To Simulate Power System Dynamic response.
To explain Torsional characteristics with examples.
To create synchronous machine model and to analyze the load aspects of voltage stability.
To understand the principle behind transient stability enhancement methods

2. **Course pre-requisites** **:** Power System Dynamics

UNIT I TRANSIENT STABILITY ANALYSIS 9

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation: equations of motion, rotor circuit equations, stator voltage equations, Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned – Explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using implicit integration method.

UNIT II SUBSYNCHRONOUS OSCILLATIONS 9

Introduction – Turbine Generator Torsional Characteristics: Shaft system model – Examples of torsional characteristics – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Interaction with nearby DC converters.

UNIT III SUBSYSNCHRONOUS RESONANCE (SSR) 9

Subsysnchronous Resonance (SSR): Characteristics of series –Compensated transmission systems – Self-excitation due to induction generator effect – Torsional interaction resulting in SSR – Analytical Methods – Numerical examples illustrating instability of subsynchronous oscillations – Impact of Network-Switching Disturbances: Steady-state switching – Successive network-Switching disturbances – Torsional Interaction Between Closely Coupled Units; time-domain simulation of subsynchronous resonance – EMTP with detailed synchronous machine model

UNIT IV TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS 9

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage-reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models.

UNIT V ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUB SYNCHRONOUS RESONANCE 9

Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

STATE OF ART (Not for Exam)

Modeling of Turbine and Governing systems for Dynamic Analysis

Total Hours : 45

3. ***Course outcomes:***

Students know various numerical Integration methods.

Students simulate Power System Dynamic response

Students explain Torsional characteristics with examples.

Students create synchronous machine model and analyze the load aspects of voltage stability

Students understand the principle behind transient stability enhancement methods

REFERENCES:

1. P. Kundur, Power System Stability and Control, McGraw-Hill, 1993.
2. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol.PAS-91, pp, 1643-1650, July/August 1972.
3. AU Power Lab Laboratory Manuals, Anna University, pp : 7-1 to 7-12, May 2004.

4. H. W. Dommel, EMTP THEORY BOOK, Microtran Power System Analysis Corporation, Second Edition, 1996.
5. T.V. Cutsem and C.Vournas, “Voltage Stability of Electric Power Systems”, Kluwer publishers,1998.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS512	**SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL**	3	0	0	3

1. Course objectives:

To know various numerical Integration methods.
Understand different models of LTI systems.
Analyze Transient and Frequency response and understand correlation and spectral analysis.
Understand different approaches and models in identifying non linear systems.
Explain the concepts of adaptive control and different adaptation techniques.

2. **Course pre-requisites** **:** Control System

UNIT I MODELS FOR INDENTIFICATION 9
Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models’.

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9
Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

UNIT III NON-LINEAR IDENTIFICATION AND MODEL VALIDATION 9
Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

UNIT IV ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9
Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

UNIT V CASE STUDIES 9
Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

STATE OF ART (Not for Exam)
Vehicle active suspension adaptive control systems based on intelligent methodologies.

Total Hours : 45

3. Course outcomes:
Students understand different models of LTI systems.
Students analyze Transient and Frequency response and they understand correlation and spectral analysis
Students understand different approaches and models in identifying non linear systems.

Students understand the concepts of adaptive control and different adaptation techniques

REFERENCES:

1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall International (UK) Ltd,1989.
3. Astrom and Wittenmark," Adaptive Control ", PHI
4. William S. Levine, " Control Hand Book", CRC Press,1995.
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS513	**INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN**	3	0	0	3

1. ***Course objectives:***

   To know various motor starting methods and to evaluate System Data-Voltage Drop & Acceleration time.
   To explain power factor correction methods
   To know the sources of harmonics & its Filteration Techniques.
   To understand the sources of Flicker and the ways for minimizing flickering effects.
   To understand the concept of Ground Grid.
   .

2. **Course pre-requisites** **:** Power Quality

UNIT I MOTOR STARTING STUDIES 9
Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis-Conclusions.

UNIT II POWER FACTOR CORRECTION STUDIES 9
Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltages-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

UNIT III HARMONIC ANALYSIS 9
Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

UNIT IV FLICKER ANALYSIS 9
Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT V GROUND GRID ANALYSIS 9
Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

STATE OF ART (Not for Exam)
Control Equipments for motor and generators

Total Hours : 45

3. ***Course outcomes:***

Students know various motor starting methods and evaluate System Data-Voltage Drop & Acceleration time
Students know the sources of harmonics & its Filteration Techniques
Students explain power factor correction methods.
Students understand the concepts of flicker and ground grid

REFERENCES:

1. Ramasamy Natarajan, ”Computer-Aided Power System Analysis”, Marcel Dekker Inc., 2002.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS514	**HIGH VOLTAGE DIRECT CURRENT TRANSMISSION**	**3**	**0**	**0**	**3**

1. Course objectives:

Compare AC and DC transmission and understand the concepts of DC power transmission technology.
Analyse HVDC converters in detail and understand the concepts of HVDC system control.
Understand the application, types, control and protection of MTDC systems.
Solve AC/DC load flow problems.
Simulate HVDC system
.

2. **Course pre-requisites** **:** Power Electronics

UNIT I DC POWER TRANSMISSION TECHNOLOGY 6
Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 12
Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.
General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

UNIT III MULTITERMINAL DC SYSTEMS 9
Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9
Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow - Case studies.

UNIT V SIMULATION OF HVDC SYSTEMS 9
Introduction – System simulation: Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation – Dynamic intraction between DC and AC systems.

STATE OF ART (Not for Exam)
Transient stability analysis of DC network models and solution methodology, Transient stability improvement using DC link control.

Total Hours : 45

3. Course outcomes:

Students understand the concepts of DC power transmission technology.
Students analyse HVDC converters and understand the concepts of HVDC system control
Students understand the application, types, control and protection of MTDC systems.
Students solve AC/DC load flow problems
Students simulate HVDC system

REFERENCES:

1. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
2. J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
3. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
4. Erich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS515	**WIND ENERGY CONVERSION SYSTEMS**	**3**	**0**	**0**	**3**

1. Course objectives:

To understand the various components of WECS and WECS schemes.
To design a Wind Turbine.
To develop Generator model.
To understand the need of variable speed systems.
To explain the importance of WECS in various countries.
.

2. **Course pre-requisites** **:** Renewable Energy sources

UNIT I INTRODUCTION 9
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES 9
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9
Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS 9

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

STATE OF ART (Not for Exam)

Various Maximum power point Tracking techniques for wind energy systems.

Total Hours : 45

3. ***Course outcomes:***

Students understand the various components of WECS and WECS schemes.
Students design Wind Turbine and develop generator model
Students understand the need of variable speed systems.

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
4. S.Heir "Grid Integration of WECS", Wiley 1998.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS516	**SOFT COMPUTING TECHNIQUES**	3	0	0	3

1. ***Course objectives:***

Understand different approaches and architecture of intelligent control.
Explain the concepts of artificial neural networks, their mathematical model and data processing.
Understand the concepts of fuzzy logic system.
Solve control problems using genetic algorithm.
Apply genetic algorithm in power system optimization problems
.

2. **Course pre-requisites :**

UNIT I INTRODUCTION 9

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madeline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

UNIT V HYBRID SOFT COMPUTING TECHNIQUES & APPLICATIONS 9

Neuro- Fuzzy and Genetic-Neuro hybrid systems,GA application to power system optimisation problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.

STATE OF ART (Not for Exam)

Application of Genetic assisted neural network, Innovative optimization in computational Intelligent techniques

Total Hours : 45

3. ***Course outcomes:***

Students understand different approaches and architecture of intelligent control.
Students understands the concepts of artificial neural network and fuzzy logic system
Students solve control problems using genetic algorithm and apply genetic algorithm in power system optimization problems

REFERENCES:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS517	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	3	0	0	3

1. ***Course objectives:***

To understand the importance of Renewable Energy Systems.
To explain the principle of operation of IG, PMSG, SCIG and DFIG.
To explain the operation of various inverters & converters.
To analyze wind & PV systems.
Too know the importance of Hybrid systems.

.

2. **Course pre-requisites** : Power Electronics
Renewable Energy Sources

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG**.**

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

STATE OF ART (Not for Exam)

Smart Grid, Role of Multilevel inverter for grid connected PV system.

Total Hours : 45

3. ***Course outcomes:***

Students understand the importance of Renewable Energy Systems.
Students explain the principle of operation of IG, PMSG, SCIG and DFIG
Students explain the operation of various inverters & converters
Students analyze wind & PV systems and know the importance of hybrid systems

REFERENCES:

1. Rashid .M. H "power electronics Hand book", Academic press, 2001.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS518	**APPLICATIONS OF MEMS TECHNOLOGY**	3	0	0	3

1. ***Course objectives:***

Understand the concepts of MEMS like micro fabrication, Crystal planes and orientation, flexural beam bending analysis resonant frequency and quality factor.
Explain Principle, material, design, fabrication and application of electrostatic sensors.
Explain Principle, material, design, fabrication and application of thermal couples, thermal bimorph sensors and thermal resistor.

Understand the concepts of piezoelectric sensing and actuation.

.

2. **Course pre-requisites** **:** Linear Integrated Circuits

UNIT I MEMS: MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

STATE OF ART (Not for Exam)

MEMS devices for bio-medical applications.

Total Hours : 45

3. ***Course outcomes:***

Students understand the concepts of micro fabrication, Crystal planes and orientation, flexural beam bending analysis, resonant frequency and quality factor.

Students explain principle, material, design, fabrication and application of electrostatic sensors, thermal couples, thermal bimorph sensors and thermal resistor

Students understand the concepts of piezoelectric sensing and actuation

REFERENCES:

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou , "Fundamentals of microfabrication",CRC Press, 1997.
3. Boston , "Micromachined Transducers Sourcebook",WCB McGraw Hill, 1998.
4. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS519	**NANO SCIENCE AND TECHNOLOGY**	**3**	**0**	**0**	**3**

1. ***Course objectives:***

To classify nano structures and different Fabrication methods.
To explain different techniques in NANO Technology.
To understand inorganic semiconductor nanostructures.
To know the applications of Nanodevices

2. **Course pre-requisites** **:**Linear Integrated Circuits

UNIT I INTRODUCTION AND CLASSIFICATION 12

Classification of nanostructures, nanoscale architecture – Effects of the nanometre length scale – Changes to the system total energy, changes to the system structures, vacancies in nanocrystals, dislocations in nanocrystals – Effect of nanoscale dimensions on various properties – Structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems.

Fabrication methods – Top down processes – Milling, lithographics, machining process – Bottom-up process – Vapour phase deposition methods, plasma-assisted deposition process, MBE and MOVPE, liquid phase methods, colloidal and solgel methods – Methods for templating the growth of nanomaterials – Ordering of nanosystems, self-assembly and self-organisation – Preparation, safety and storage issues

UNIT II GENERIC METHODOLOGIES FOR NANOTECHNOLOGY 8

Characterization: General classification of characterization methods – Analytical and imaging techniques – Microscopy techniques - Electron microscopy, scanning electron microscopy, transmission electron microscopy, STM, field ion microscopy, scanning tunnelling microscopy, atomic force microscopy – Diffraction techniques – Spectroscopy techniques – Raman spectroscopy – Surface analysis and depth profiling – Mechanical properties, electron transport properties, magnetic and thermal properties.

UNIT III INORGANIC SEMICONDUCTOR NANOSTRUCTURES 8

Quantum confinement in semiconductor nanostructures - Quantum wells, quantum wires, quantum dots, superlattices, band offsets and electronic density of states – Fabrication techniques – Requirements, epitaxial growth, lithography and etching, cleared edge overgrowth – Growth on vicinal substrates, strain-induced dots and wires, electrostatically induced dots and wires, quantum well width fluctuations, thermally annealed quantum wells and self-assembly techniques

UNIT IV SELF ASSEMBLING NANOSTRUCTURED MOLECULAR MATERIALS AND DEVICES 9

Introduction – Building blocks – Principles of self-assembly, non-covalent interactions, intermolecular packing, nanomotors – Self assembly methods to prepare and pattern nanoparticles – Nanopartcles from micellar and vesicular polymerization, functionalized nano particles, colloidal nanoparticles crystals, self-organizing inorganic nano particles, bio-nanoparticles – nanoobjects.

UNIT V NANODEVICES AND THEIR VARIOUS APPLICATIONS: 8

Nanomagnetic materials – Particulate nanomagnets and geometrical nanomagnets – Magneto resistance – Probing nanomagnetic materials – Nanomagnetism in technology – Carbon nanotubes – fabrication-applications – Organic FET, organic LED's – Organic photovoltaics – Injection lasers, quantum cascade lasers, optical memories, electronic applications, colulomb blockade devices.

STATE OF ART (Not for Exam)

Nano science in solar energy, Nano technology in computer processing.

Total Hours : 45

3. Course outcomes:

Students understand the basics of nano science and explains different fabrication methods
Students explain different techniques in NANO Technology
Students understand inorganic semiconductor nanostructures and know the applications of nano devices

REFERENCES:

1. Kelsall Robert W Ian Hamley, Mark Geoghegan, "Nanoscale Science and Technology", Wiley Eastern, 2004.
2. Michael Kohler, Wolfgang, Fritzsche, "Nanotechnology: Introduction to Nanostructuring Techniques", 2004.
3. William Goddard, Donald W Brenner, "Handbook of Nano Science Engineering and Technology", CRC Press, 2004.
4. Bharat Bhushan, "Springer Handbook of Nanotechnology", 2004.
5. Charles P Poole, Frank J Owens, "Introduction to Nanotechnology", John Wiley and Sons, 2003.
6. Mark Ratner, Danial Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
7. Gregory Timp, "Nanotechnology", Springer-Verlag, 1999.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS520	**POWER QUALITY**	3	0	0	3

1. Course objectives:

Define terminologies in power quality
Understand different Sources of sags and interruptions and estimate voltage sag performance.
Understand different sources of over voltages, surge arrestors, filters and power conditioners.
Analyse transients using PSCAD and EMPT
Understand harmonic distortion and power quality monitoring.

2. **Course pre-requisites** **:** High Voltage Engineering

UNIT I INTRODUCTION TO POWER QUALITY 9
Terms and definitions: Overloading, under voltage, sustained interruption; sags and swells; waveform distortion, Total Harmonic Distortion (THD), Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT II VOLTAGE SAGS AND INTERRUPTIONS 9
Sources of sags and interruptions, estimating voltage sag performance, motor starting sags, estimating the sag severity, mitigation of voltage sags, active series compensators, static transfer switches and fast transfer switches.

UNIT III OVERVOLTAGES 9
Sources of over voltages: Capacitor switching, lightning, ferro resonance; mitigation of voltage swells: Surge arresters, low pass filters, power conditioners – Lightning protection, shielding, line arresters, protection of transformers and cables, computer analysis tools for transients, PSCAD and EMTP.

UNIT IV HARMONICS 9
Harmonic distortion: Voltage and current distortion, harmonic indices, harmonic sources from commercial and industrial loads, locating harmonic sources; power system response characteristics, resonance, harmonic distortion evaluation, devices for controlling harmonic distortion, passive filters, active filters, IEEE and IEC standards.

UNIT V POWER QUALITY MONITORING 9
Monitoring considerations: Power line disturbance analyzer, power quality measurement equipment, harmonic / spectrum analyzer, flicker meters, disturbance analyzer, applications of expert system for power quality monitoring.

STATE OF ART (Not for Exam)
Power Quality conditioners - shunt and series compensators - DSTATCOM - Dynamic voltage restorer unified power quality conditioners- case studies

Total Hours : 45

3. Course outcomes:

Students understand terminologies in power quality, different sources of sags and interruptions.
Students estimate voltage sag performance.
Students understand different sources of over voltages, surge arrestors, filters and power conditioners.
Students analyse transients using PSCAD and EMPT.
Students understand harmonic distortion and power quality monitoring

REFERENCES:

1. Roger.C.Dugan, Mark.F. McGranagham, Surya Santoso, H.Wayne Beaty, 'Electrical Power Systems Quality' McGraw Hill, 2003.
2. PSCAD User Manual.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS521	**ELECTRICAL TRANSIENTS IN POWER SYSTEMS**	**4**	**0**	**0**	**4**

1. Course objectives:

Understand Electrical Transients in power systems
Explain the concepts of traveling waves and propagation
Model transmission lines as distributed parameter systems.
Discuss issues related to insulation coordination, grounding and limiting of surge effects
Develop techniques related to reflections at transition points in lines and cables
Explain multi conductor transients and distributed parameter modeling for components and shielding issues.

2. **Course pre-requisites** **:** Transmission and Distribution
Power Systems

UNIT I TRAVELLING WAVES ON TRANSMISSION LINE 12
Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behavior of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave.

UNIT II COMPUTATION OF POWER SYSTEM TRANSIENTS 12
Principle of digital computation – Matrix method of solution, Modal analysis transforms, Computation using EMTP – Simulation of switches and non-linear elements.

UNIT III LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES 12
Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and

re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)

UNIT IV BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION 12
Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behavior of the transformer core under surge condition – Rotating machine – Surge in generator and motor

UNIT V INSULATION CO-ORDINATION 12
Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level –overvoltage protective devices – lightning arresters, substation earthing.

STATE OF ART (Not for Exam)
Power system stability tools-Transient stability program, Small signal analysis program, EMTP programs, Real time Simulators.

Total Hours : 60

3. ***Course outcomes:***

Students understand Electrical Transients in power systems
Students explain the concepts of traveling waves and propagation
Students model transmission lines as distributed parameter systems and discuss issues related to insulation coordination, grounding and limiting of surge effects
Students develop techniques related to reflections at transition points in lines and cables
Students explain multi conductor transients and distributed parameter modeling for components and shielding issues.

REFERENCES:

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
3. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
4. Rakosh Das Begamundre, "Extra High Voltage AC Transmission Engineering", (Second edition) New age International (P) Ltd., New Delhi, 1990.
5. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
6. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
7. Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with Gas Insulated System', CIGRE, 33-13, pp. 1-20.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS522	**SYSTEM THEORY**	4	0	0	4

1. ***Course objectives:***

To understand the basic concepts of system theory and its application to practical systems.
To design and conduct experiments, analyze and interpret data and effectively use modern technology in problem solving and research using appropriate mathematical and computational methodologies.
To understand stability analysis of systems using Lyapunov's theory.

To understand modal concepts and design of state and output feedback controllers and estimators.

2. **Course pre-requisites** **:** Control System

UNIT I STATE VARIABLE REPRESENTATION 12

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

UNIT II SOLUTION OF STATE EQUATION 12

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes-Role of Eigen values and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 12

Controllability and Observability-Stabilizability and Detect ability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILITY 12

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

UNIT V MODAL CONTROL 12

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

STATE OF ART (Not for Exam)

Advanced Stability analysis using Barvbalat's lemma

Total Hours : 60

3. ***Course outcomes:***

Students understand the basic concepts of system theory and its application to practical systems.

Students design and conduct experiments, analyze and interpret data and effectively use modern technology in problem solving using appropriate mathematical and computational methodologies.

Students understand stability analysis of systems using Lyapunov's theory

Students understand the concepts and design of state and output feedback controllers and estimators.

REFERENCES:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.

Course Code	Course Name	Contact Hours			
		L	T	P	C

15PPS523	FLEXIBLE AC TRANSMISSION SYSTEMS	3	0	0	3

1. ***Course objectives:***

To develop expression for computation of fundamental parameters of lines.
To categorize the lines into different classes and develop equivalent circuits for these classes.
To analyze the voltage distribution in insulator strings and cables and methods to improve the same.
To analyze the various parameters involved in the transmission lines
To study the modeling and performance of transmission lines

2. **Course pre-requisites** : Power Electronics

UNIT I INTRODUCTION 9
Reactive power control in electrical power transmission lines -Uncompensated transmission line - series compensation – Basic concepts of static Var Compensator (SVC) – Thyristor Switched Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9
Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of svc for power flow and transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.

UNIT III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS 9
Operation of the TCSC – Different modes of operation – Modelling of TCSC – Variable reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping-SSR Mitigation.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9
Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow –Modelling of SSSC in load flow and transient stability studies. Applications: SSR Mitigation-UPFC and IPFC

UNIT V COMBINED COMPENSATORS: UPFC AND IPFC 9
Introduction-The Unified Power Flow Controller- Basic operating principle-conventional transmission control capabilities-independent real and reactive power flow control-basic control system for P and Q control-dynamic performance- The Interline Power Flow Controller- Basic operating principles and characteristics-control structure-computer simulation- practical and application considerations-Generalized and multi functional FACTS controllers

STATE OF ART (Not for Exam)
Role of FACTS devices in smart grid – FACTS devices in HVDC transmission systems.

Total Hours : 45

3. ***Course outcomes:***

Students develop expression for computation of fundamental parameters of lines, categorize the lines into different classes and develop equivalent circuits for these classes.
Students analyze the voltage distribution in insulator strings and cables and various parameters involved in the transmission lines.

Students study the modeling and performance of transmission lines

REFERENCES:

1. R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006
3. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008
4. A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS524	**ENERGY AUDITING AND MANAGEMENT**	3	0	0	3

1. ***Course objectives:***

   To study about the basic concept of energy audit.
   To know about the principles of energy management.
   To provide a platform for understanding the basic concepts of power factor improvement.

2. **Course pre-requisites** : Generation, Utilization and Conservation of energy

UNIT I BASIC PRINCIPLES OF ENERGY AUDIT 9
Energy audit – definition, concept, type of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles,Energy conservation schemes – Energy audit of industries – energy saving potential, energy audit of process industry,thermal power station, building energy audit.

UNIT II ENERGY MANAGEMENT 9
Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting,monitoring, reporting – Energy manager, Qualities and functions, Language, Questionnaire – check list for top management..

UNIT III ENERGY EFFICIENT MOTORS 9
Energy efficient motors, factors affecting deficiency, loss distribution, constructional details, characteristics – variable speed, variable duty cycle systems, RMS hp- voltage variation –voltage unbalance – over motoring – motor energy audit.

UNIT IV POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS 9
Power factor - methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on p.f, p.f motor controllers – Good lighting system design and practice, lighting control, lighting energy audit – Energy Instruments – watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's.

UNIT V ECONOMIC ASPECTS AND ANALYSIS 9
Economics analysis – Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis - Energy efficient motors - calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

STATE OF ART (Not for Exam)
Emerging Methods in Energy Management system and its Evaluation.

Total Hours : 45

3. ***Course outcomes:***

Students know the basic concept of energy audit and principles of energy management
Students understand the basic concepts of power factor improvement.

REFERENCES:

1. Murphy W.R. and G.Mckay Butter worth , "Energy Management", Heinemann Publications.
2. Paul o' Callaghan, "Energy Management",Mc-Graw Hill Book Company – 1st edition; 1998.
3. John.C.Andreas, "Energy Efficient Electric Motors", Marcel Dekker Inc Ltd – 2nd edition; 1995.
4. W.C.Turner, "Energy Management Handbook", John Wiley and Sons, Fifth edition, 2009.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS525	**POWER SYSTEM OPTIMIZATION**	3	0	0	3

1. ***Course objectives:***

To understand the fundamentals of power system.
To optimize multiobjective generation scheduling problem by weighted min-max method.
To understand and solve economic and emission load dispatch problem by Risk/Dispersion method and ANN methods.
To solve Economic Dispatch Problem by genetic algorithm method.
To solve multiobjective optimization problem by ant colony,PSO and Tabu Search algorithms.

2. **Course pre-requisites** : Power System Operation and Control

UNIT I REVIEW OF POWER SYSTEMS 9
Generator Operating Cost- Economic Load Dispatch- Without and with loss-Loss Coefficient using Sensitivity Factors-Economic Dispatch for Active and Reactive Power Balance- Economic Dispatch using Loss Formula which is Function of Real and Reactive Power-Optimal Power Flow Based on Gradient Method-Newton Method.

UNIT II MULTIOBJECTIVE GENERATION SCHEDULING 9
Multiobjective optimization-Weighting Method-Min –Max Optimum-å Constraint Method-Weighted Min-Max method-Utility Function Method-Global criterion method-Fuzzy set theory in Power System-Thermal Plant-Active and Reactive Power Balance.

UNIT III STOCHASTIC MULTIOBJECTIVE GENERATION SCHEDULING 9
Multiobjective Stochastic Optimal thermal Power Dispatch- å Constraint Method-Surrogate worth Tradeoff method-Weighting Method –Risk/Dispersion method-ANN methods-Economic- Emission Load Dispatch.

UNIT IV EVOLUTIONARY PROGRAMMING FOR GENERATION SCHEDULING 9
Introduction to GA-Economic Dispatch Problem-GA Solution Methodology-GA Solution Based on Real Power Search

UNIT V ADVANCED OPTIMIZATION 9

Swarm Intelligence-Ant Colony –Fish Flock-Particle Swarm Optimization – Multi Objective PSO- Tabu Search

STATE OF ART (Not for Exam)
Tabu search application in Fault section estimation.

Total Hours : 45

3. ***Course outcomes:***

Students understand the fundamendals of power system
Students understand and solve economic and emission load dispatch problem by Risk/Dispersion method and ANN methods
Students solve Economic Dispatch Problem by genetic algorithm method
Students solve multiobjective optimization problem by ant colony, PSO and Tabu Search algorithms.

REFERENCES:

1. Kothari D.P. and Dhillon .J.S.”Power System Optimization”, Prentice Hall of India, New Delhi, 2004.
2. 2. Kennedy J. and Eberhart.R.C, “SwarmIntelligence”, SanFrancisco, CA, Morgan Kaufmann, 2001.
3. Glover, F., “Tabu Search-Part II”, ORSA J.Comput.,1990, 2,(1), pp.4-32.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS526	**MODERN POWER GENERATION SYSTEMS**	3	0	0	3

1. ***Course objectives:***

To understand bio energy generation and utilization.
To study Solar Photovoltaic systems, Solar thermal systems, Solar Energy Centre.
To understand various renewable power generation schemes.
To understand production of energy from geothermal, ocean and fuel cells.
To create awareness related to IREDA

2. **Course pre-requisites** **:** Renewable Energy Sources

UNIT I RENEWABLE ENERGY POLICY AND LEGISLATION 9
Rural Energy - Biogas plants - Improved biomass cooking stoves - Biomass production and utilization – briquetting and gasifiers - Integrated Rural Energy Programme.

UNIT II SOLAR ENERGY 9
Solar Photovoltaic systems - Solar thermal systems - Solar Energy Centre.

UNIT III POWER GENERATION 9
Biomass Power - Wind Power - Small Hydro Power - Solar photovoltaic Power – Solar Thermal Power - Energy from Urban, Municipal and Industrial Wastes.

UNIT IV NEW TECHNOLOGY 9
Geothermal energy - ocean energy - alternate fuel for surface transport including electric vehicles - chemical sources of energy including fuel cells and hydrogen energy.

UNIT V RECENT TECHNIQUES **9**

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

STATE OF ART (Not for Exam)

Real time data control implementation in smart grid using MATLAB simulink.

Total Hours : 45

3. Course outcomes:

Students understand bio energy generation and utilization, various renewable power generation schemes and production of energy from geothermal, ocean and fuel cells

Students study Solar Photovoltaic systems, Solar thermal systems, Solar Energy Centre

REFERENCES:

1. G. D. Rai,"Non Conventional Energy Sources", ISBN: 8174090738, Khanna Publishers.
2. Dan Chiras, "The Homeowner's Guide to Renewable Energy", New Society Publishers,
3. "Renewable energy engineering and technology", TERI Press.
4. "TERI Energy Data Directory & Yearbook" (TEDDY) 2005/06.
5. "National Energy Map for India", ISBN: 81-7993-064-5.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS527	**POWER SYSTEM SECURITY**	3	0	0	3

1. Course objectives:

To understand the basics of power system security

To estimate measurements related to state estimation.

To develop contingency algorithms based on network sensitivity factors approach.

To optimize security constrained linear problem by sensitivity methods

To know the recent techniques of security assesment

2. **Course pre-requisites** **:** Power System

UNIT I BASICS OF POWER SYSTEM SECURITY **9**

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

UNIT II POWER SYSTEM STATE ESTIMATION **9**

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

UNIT III SECURITY ASSESSMENT **9**

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

UNIT IV SECURITY ENHANCEMENT **9**

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

UNIT V RECENT TECHNIQUES **9**
Voltage security assessment-Transient Security assessment-methods-Comparison.

STATE OF ART (Not for Exam)
Dynamic State Estimation for Electrical Power Systems.

Total Hours : 45

3. Course outcomes:

Students understand the basics of power system security and state estimation
Develop contingency algorithms based on network sensitivity factors approach.
Students optimize security constrained linear problem by sensitivity methods
Students know the recent techniques of security assessment

REFERENCES:

1. Wood, A.J. and Wollenberg, B.F., "Power generation, Operation and Control", John Wiley and Sons,1984.
2. Wood, A.J. and Woolenberg, "Power generation operation for security" – John Wiley and sons, 1989.
3. Abdullah Khan, M (Editor), "Real time control of power system for security", vol.2, Proceedings of summer school, College of Engineering, Madras, 1976.
4. Handsching.E, "Real time control of Electric Power Systems", Elsevier publishing Co., Amsterdam, 1972.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS528	**CONTROL SYSTEM SOFTWARE**	**3**	**0**	**0**	**3**

1. Course objectives:

Understand the basic concepts of MATLAB
Use MATLAB for mathematical applications
Understand Simulink concepts in MATLAB
Simulate programs and Simulink blocks using various commands
Study different toolboxes in MATLAB

2. **Course pre-requisites** **:** Control System

UNIT I MATLAB BASICS **9**
Introduction - Matrices and Vectors - Matrix and Array operations - Build in functions - Saving and loading data – Script files - Function files - Language specific features.

UNIT II MATLAB APPLICATIONS AND GRAPHICS **9**
Applications in linear algebra, Curve fitting and interpolation, Data analysis and statistics - Ordinary differential equations and nonlinear algebraic equations - Basic 2-D plots-multiple graphs layout - Handle graphics.

UNIT III SIMULINK MODELS **9**

Starting simulink - Selecting objects - Blocks - Connecting blocks - Working with signals – Annotations - Working with data types - Creating subsystems.

UNIT IV SIMULATION 9
Running a simulation with menu commands - Simulation parameter - Dialogue box - Viewing output trajectories -Equilibrium point determination - Running a simulation from command line.

UNIT V MATLAB TOOLBOXES 9
Control system toolbox: Linear models - MIMO models - Interconnecting linear models - Continuous/Discrete conversions - LTI viewer - Functions for time and frequency response - Simulink LTI viewer - Principles of symbolic math toolbox.

STATE OF ART (Not for Exam)
Real time control system software, Source code control system

Total Hours : 45

3. Course outcomes:

Students understand the basic concepts of MATLAB and use MATLAB for mathematical applications
Students understand Simulink concepts in MATLAB and simulate programs and Simulink blocks using various commands

REFERENCES:

1. Rudra Pratap, "Getting Started with MATLAB 7", Oxford University Press, 2009.
2. Duane C. Hanselman, and Bruce Littlefield , "Mastering Matlab", Prentice Hall, 2012.
3. Simulink Manual , The Mathworks Inc.,2000, www.mathworks.com.
4. Control System Toolbox Manual , The Mathworks Inc.,2000, www. mathworks.com

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS529	**VIRTUAL INSTRUMENTATION**	3	0	0	3

1. Course objectives:

Understand the architecture of Virtual Instrument
Understand basics concepts of programming using VI
Write program for specific applications
Explain the concepts of Data Acquisition and VI interfacing
Know the applications of VI

2. **Course pre-requisites** **:** Digital Signal Processing

UNIT I REVIEW OF VIRTUAL INSTRUMENTATION 9
Historical Perspective - Advantages etc - Block diagram and architecture of a virtual instrument.

UNIT II DATA FLOW TECHNIQUES 9
Graphical programming in data flow - comparison with conventional programming

UNIT III PROGRAMMING TECHNIQUE 9

VIS and Sub-VIS - Loops and charts- Arrays - Clusters - Graphs - Case and sequence structures - Formula nodes -Local and global variables - String and file I/O.

UNIT IV DATA ACQUISITION AND INSTRUMENT INTERFACE 9

ADC - DAC - DIO - Counters and timers - PC hard ware structure - Timing - interrupts - DMA - Software and hardware installation - Current loop - RS –232 C / RS – 485- GPIB- USB and PCMCIA.

UNIT V ANALYSIS TOOLS AND APPLICATIONS 9

Some tools from the advanced analysis tools relevant to the discipline may be included Eg. Fourier transform – Power spectrum - Correlation methods - Windowing and filtering. VI application in various fields – VISA and IVI – Image acquisition and processing.

STATE OF ART (Not for Exam)

Virtual instrumentation for control applications,Application of VI in nuclear physics.

Total Hours : 45

3. Course outcomes:

Students understand architecture of Virtual Instrument
Understand basics concepts of programming using VI and write programs
Students explain the concepts of Data Acquisition and VI interfacing and know the applications of VI

REFERENCES:

1. Jovitha Jerome, " Virtual Instrumentation using labview" , Prentice Hall,India,2010.
2. Sanjav Gupta and Joseph John, "Virtual Instrumentation using Labview", Tata McGraw Hill, May 2010.
3. Cory L.Clark, "LabVIEW Digital Signal Processing and Digital Communications", Tata McGraw Hill, 2005.
4. Gray Johnson,'Lab VIEW Graphical Programming' 4th Edition., McGraw Hill, August-2006.
5. Jeffrey Travis, 'LabVIEW for Everyone', 3rd Edition, Prentice Hall, 2006.

Course Code	Course Name	Contact Hours			
		L	T	P	C
15PPS530	**ADVANCED ELECTRIC DRIVES AND CONTROL**	3	0	0	3

1. Course objectives:

Understand the basic concepts of advanced electric drives
Understand the application of digital signal processing in electric drives
Explain the concepts of switching and types of modulation techniques
Apply neural network and fuzzy controllers in electric drives

2. **Course pre-requisites** : Electric Drives and Control

UNIT I INTRODUCTION 09

Need for advanced controls - Principle factor affecting the choice of drive – Parameter identification techniques for electric motors – Electromagnetic compatibility of electric drives – Different options for an adjustable speed electric drive – Simulation of electrical drives – Advanced control strategies for electrical drives – DSP based control of electric drives.

UNIT II DSP CONTROLLERS AND INSTRUCTION SET 09

TMS 320 family overview – 320 C24X Series of DSP controllers – Architecture overview – C24X CPU internal bus structure – Memory – Central processing unit – Memory and I/O spaces – Overview of Memory and I/O spaces –Program control –Address modes – System configuration and interrupts – Clocks and low power modes –Digital input/output (I/O). Instruction set: Assembly language instructions – Instruction set summary – Instruction description –Accumulator, arithmetic and logic instructions – Auxiliary register and data page pointer instructions – TREG, PREG, and Multiply instructions – Branch instructions – Control instructions – I/O and memory instructions.

UNIT III PWM INVERTER CONTROL 09

Inverter – Operation principle – Inverter switching – Unipolar – Bipolar – Inverter dead time– inverter modulation –Different types – Sine Triangle – Analysis of Sine Triangle Modulation – Trapezoidal Modulation – Third harmonic Modulation – Analysis of Third Harmonic Modulation – Output filter requirement for different PWM techniques.

UNIT IV SPACE VECTOR MODULATION 09

Concept of a Space Vector – dq0 Components for Three-phase sine wave source/1evel –dq0 Components for Voltage Source Inverter (VSI) operated in Square Wave Mode –Synchronously rotating reference frame – Space Vector Modulation (SVM) – Principle –SVM compared to regular sampled PWM Phase Lag reference for SVM – Naturally sampled SVM – Analytical solution for SVM – Harmonic losses for SVM – Placement of Zero Space Vector – Discontinuous Modulation – Phase Lag reference for discontinuous PWM.

UNIT V NEURAL NETWORK AND FUZZY CONTROLLERS 09

Current and speed control of Induction Motor – Current control algorithm – Sensorless motion control strategy – Induction Motor Controller using VHDL design. Fuzzy Logic Control of a Synchronous Generator – System representation –VHDL Modelling –FPGA implementation.

Total Hours:45

3. Course outcomes:

Students understand the basic concepts of advanced electric drives
Apply digital signal processing in electric drives
Students explain the concepts of switching and types of modulation techniques
Apply neural network and fuzzy controllers in electric drives

REFERENCES

1. Bimal K. Bose, "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, 1997.
2. Grafame Holmes. D and Thomas A. Lipo, "Pulse Width Modulation for Power Converters – Principles and Practice", IEEE Press, 2003.