PUNJAB TECHNICAL UNIVERSITY

PUNJAB INSTITUTE OF TECHNOLOGY, KAPURTHALA

PTU Main Campus

Scheme and Syllabus

of

Master of Technology

Electrical Engineering
(Power System)

Batch- 2015& onwards

8/5/15

8/5/2015

08/05/15
DR. A.S. BALI

Gagandeep
8/5/2015

08/05/2015

Punjab Institute of Technology, Kapurthala – PTU Main Campus

M. Tech Electrical Engineering (Power System)

Semester- I

Course Code	Course Title	Load Allocation L T P Hours/Week	Marks Distribution Internal External Total Marks	Credits
EERM-101	Research Methodology	3 1 0 4	40 60 100	4
EEPS- 101	Power System Analysis and Design	3 1 0 4	40 60 100	4
EEPS-102	FACTS Devices and Power Transmission	3 1 0 4	40 60 100	4
EEPS-103	Power System Quality Assessment	3 1 0 4	40 60 100	4
EEPS-104	Advanced Relaying and Protection	3 1 0 4	40 60 100	4
	Total	15 5 0 20	200 300 500	20

8/5/15 8/5/2015 08/5/2015 Gagandeep 8/5/2015 08/5/15 9.5.BW

Semester -II

Course Code	Course Title	Load Allocation L T P Hours/Week	Marks Distribution Internal External Total Marks	Credits
EEPS-201	Power System Operation and Control	3 1 0 4	40 60 100	4
EEPS- 202	Power System Restructuring and Deregulation	3 1 0 4	40 60 100	4
EEPS-203	Power System Dynamics and Stability	3 1 0 4	40 60 100	4
EEPS-204X	Elective-I	3 1 0 4	40 60 100	4
EEPS-205Y	Elective-II	3 1 0 4	40 60 100	4
	Total	15 5 0 20	200 300 500	20

Semester –III

Course Code	Course Title	Load Allocation L T P Hours/Week	Marks Distribution Internal External Total Marks	Credits
EEPS-301X	Elective –III	3 1 0 4	40 60 100	4
EEPS- 302 Y	Elective-IV	3 1 0 4	40 60 100	4
EEPS-303	Project	0 0 4 4	40 60 100	4
EEPS-304	Seminar	0 0 2 2	100* 0 100	2
EEPS-305	Dissertation(Part-I)	0 0 6 6	60 40 100	6
	Total	6 2 6 20	280 220 500	20

8/5/15 8/5/2015 08/8/2015 Gagandeep 8/5/2015 8/5/15

Semester-IV

Course Code	Course Title	Load Allocation L T P Hours/Week	Marks Distribution Internal External Total Marks	Credits
EEPS-305	Dissertation(Part-II)	0 0 20 20	60* 40 100	20

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Punjab Technical University

Punjab Institute of Technology, Kapurthala- PTU Main Campus

M. Tech Electrical Engineering (Power System)

Elective		
Elective –I	EEPS-204A	Industrial Drives and Automation
	EEPS-204B	Advanced Power Electronics
	EEPS-204C	Distribution Automation
	EEPS-204D	Real Time Instrumentation
	EEPS-204E	Microprocessors &Microcontrollers
Elective- II	EEPS-205A	Intellectual Property Rights
	EEPS-205B	Organization and Finance in Power Sector
	EEPS-205C	Power System Planning
	EEPS-205D	Load and Energy Management
	EEPR-205E	Modern Control Theory
Elective –III	EEPS-301A	Intelligent Techniques and Applications
	EEPS-301B	Optimization Techniques
	EEPS-301C	Electric Smart Grid
	EEPS-301D	EHVAC and HVDC Transmission System
	EEPS-301E	Renewable Energy Resources
Elective-IV	EEPS-302A	High Voltage Engineering and Test Techniques
	EEPS-302B	Energy Efficient Machines
	EEPS-302C	Modelling and Dynamics of Electrical Machines
	EEPS-302D	Power System Transients
	EEPS-302E	Power system Reliability

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Punjab Institute of Technology, Kapurthala – PTU Main Campus

M. Tech Electrical Engineering (Power System)

Semester- I

Course Code	Course Title	Load Allocation L	T	P	Hours/Week	Marks Distribution Internal	External	Total Marks	Credits
EERM-101	Research Methodology	3	1	0	4	40	60	100	4
EEPS- 101	Power System Analysis and Design	3	1	0	4	40	60	100	4
EEPS-102	FACTS Devices and Power Transmission	3	1	0	4	40	60	100	4
EEPS-103	Power System Quality Assessment	3	1	0	4	40	60	100	4
EEPS-104	Advanced Relaying and Protection	3	1	0	4	40	60	100	4
	Total	15	5	0	20	200	300	500	20

Semester -II

Course Code	Course Title	Load Allocation L	T	P	Hours/Week	Marks Distribution Internal	External	Total Marks	Credits
EEPS-201	Power System Operation and Control	3	1	0	4	40	60	100	4
EEPS- 202	Power System Restructuring and Deregulation	3	1	0	4	40	60	100	4
EEPS-203	Power System Dynamics and Stability	3	1	0	4	40	60	100	4
EEPS-204X	Elective-I	3	1	0	4	40	60	100	4
EEPS-205Y	Elective-II	3	1	0	4	40	60	100	4
	Total	15	5	0	20	200	300	500	20

Semester –III

Course Code	Course Title	Load Allocation L	T	P	Hours/Week	Marks Distribution Internal	External	Total	Marks	Credits
EEPS-301X	Elective-III	3	1	0	4	40	60		100	4
EEPS- 302 Y	Elective-IV	3	1	0	4	40	60		100	4
EEPS-303	Project	0	0	4	4	40	60		100	4
EEPS-304	Seminar	0	0	2	2	100*	0		100	2
EEPS-305	Dissertation (Part-I)	0	0	6	6	60	40		100	6
	Total	6	2	6	20	280	220		500	20

Semester-IV

Course Code	Course Title	Load Allocation L	T	P	Hours/Week	Marks Distribution Internal	External	Total	Marks	Credits
EEPS-305	Dissertation (Part-II)	0	0	20	20	60*	40		100	20

*To be evaluated by Department Research Committee (DRC).
Elective-I, II, III & IV is to chosen from the set list of electives.

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Elective **M. Tech Electrical Engineering (Power System)**

Elective –I	EEPS-204A	Intelligent Techniques and Applications
	EEPS-204B	Industrial Drives and Automation
	EEPS-204C	Renewable Energy Resources
	EEPS-204D	High Voltage Engineering and Test Techniques
Elective- II	EEPS-205A	Advanced Power Electronics
	EEPS-205B	Microprocessors &Microcontrollers
	EEPS-205C	Real Time Instrumentation
	EEPS-205D	Optimization Techniques
Elective –III	EEPS-301A	Energy Efficient Machines
	EEPS-301B	Modelling and Dynamics of Electrical Machines
	EEPS-301C	EHVAC and HVDC Transmission System
	EEPS-301D	Power System Transients
Elective-IV	EEPS-302A	Power system Reliability
	EEPS-302B	Power System Planning
	EEPS-302C	Load and Energy Management
	EEPS-302D	Organization and Finance in Power Sector

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EERM-101 RESEARCH METHODOLOGY

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

METHODS OF RESEARCH: Nature and Objectives of research; historical, descriptive and experimental. Study and formulation of research problem. Scope of research and formulation of hypotheses; Feasibility, preparation and presentation of research proposal.

INTRODUCTION TO STATISTICAL ANALYSIS: Measures of central tendency and dispersion: mean, median, mode, range, mean deviation and standard deviation. Regression and correlation analysis. Probability and probability distributions; Binomial, Poisson, Geometric, Negative binomial, Uniform, Exponential, Normal and Log-normal distribution. Basic ideas of testing of hypotheses; Tests of significance based on normal, t and Chi-square distributions. Analysis of variance technique.

DESIGN OF EXPERIMENTS: Basic principles, study of completely randomized and randomized block designs. Edition and tabulation of results, presentation of results using figures, tables and text, quoting of references and preparing bibliography. Use of common softwares like SPSS, Mini Tab and/or Mat Lab. For statistical analysis.

BOOKS RECOMMENDED:

1. Borth Wayne C., *The Craft of Research*, Chicago Guides to Writing Edition and Publishing.
2. Johnson R.A., *Probability and Statistics*, PHI, New Delhi.
3. Meyer P.L., *Introduction to Probability and Statistical, Applications*, Oxford, IBH.
4. Hogg, R.V. and Craig A.T., *Introduction to Mathematical Statistics*, MacMillan.
5. Goon, A.M., Gupta, M.K. and Dasgupta, *Fundamentals of Statistics*, Vol. I: World Press.
6. Gupta, S.C. and Kapoor V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons.

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EEPS-101 POWER SYSTEM ANALYSIS AND DESIGN

Internal Marks: 40
External Marks: 60
Total Marks: 100

L	T	P
3	1	0

OVERVIEW: Review of modeling of power system components, formulation and modifications of the Impedance and Admittance matrices, storage techniques.

OPTIMAL POWER FLOW Review of load flow with and without tap changing and phase shifting transformer, load flow for radial (distribution) systems, Optimal power flow (OPF) problem formulation and solution techniques.

FAULT STUDIES: Three Phase Networks, Three Phase Network Elements, Balanced Network, Transformation Matrices, Three Phase Unbalanced network Elements, Algorithm formation of Three Phase Bus Impedance Matrix, Modification of Three Phase Bus Impedance Matrix for changes in the Network.

NETWORK FAULTS AND CEONTINGENCY ANALYSIS: Fault computation using Z – Bus, Short Circuit Calculation for Three Phase Network using z-bus, Contingency analysis for power system.

POWER SYSTEM SECURITY: Factors affecting security, Contingency analysis, Network sensitivity using load flow, correcting the generation dispatch by using sensitivity method and linear programming.

STATE ESTIMATION IN POWER SYSTEMS: Method of least-squares, State estimation of AC network, Detection and identification of bad measurements, Network observability and pseudo measurements, Application of power system state estimation.

BOOKS RECOMMENDED:

1. Grainger J.D., *Power System Analysis*, McGraw-Hill, Inc, Singapore.
2. Wood A.J. and Wollenberg B.F.,*Power Generation, Operation and Control* John Wiley and Sons, New York, USA.
3. Glover J.D. and Sarma,*Power System Analysis and Design* PWS Publishing Company, Boston, USA.
4. Stagg G. W. and Elabiad A. H.,*Computer Methods in Power System Analysis* McGraw Hill, New York.
5. Pai M. A., *Computer Techniques in Power System Analysis* , Tata McGraw Hill Publishing Co. Ltd.
6. Kusic G.L., *Computer Aided Power System Analysis* , Prentice Hall (India)
7. Arrillaga J., Arnold C.P. and Harker S.J.*Computer Modeling of Electrical Power Systems* John. Willey and Sons 1983.
8. Elgard O.I., *Electric Energy Systems An Introduction* , Tata McGraw Hill, 1971.

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EEPS-102 FACT DEVICES AND POWER TRANSMISSION

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

INTRODUCTION OF FACTS CONCEPTS: Basic of flexible alternating current transmission system (FACTS) controllers, shunt, series, combined and other controllers, FACTS technology, HVDC or FACTS, static VAR compensator (SVC) and static synchronous compensator (STATCOM), Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series, Capa citor (TCSC).Solid State Contactors (SSC) and TSSC

VOLTAGE SOURCE CONVERTERS: Basic concepts, single phase full wave bridge converter operation, three phase full wave bridge converter, sequence of valve conduction process in each phase leg, transformer connections for 12 pulse operation, three level voltage sourced converter, Pulse-width modulation (PWM) converter.

SELF AND LINE COMMUTATED CURRENT SOURCED CONVERTERS: Basic concepts, three phase full wave diode rectifier, thyristor based converter, Rectifie r and inverter operation valve voltage and commutation failure, Current sourced versus voltage sourced converters.

HARMONICS AND FILTERS: Harmonics on ac side and dc side of converter, characteristics and uncharacteristic harmonics, troubles caused by harmonics, harmonic active and passive filters.

COMBINED COMPENSATORS: Introduction, Unified power flow controller (UPFC), conventional power control capabilities, real and reactive power flow control, comparison of UPFC to series compensators, control structure, dynamic performance. Interline power flow controller basic operating principles, control structure, application considerations.

BOOKS RECOMMENDED:

1. Song Y.H. and Johns A.T., *Flexible AC Transmission Systems* , IEEE Press.
2. Hingorani N.G. and Gyragyi L., *Understanding FACTS (Concepts and Technology of Flexible AC Transmission System)*, Standard Publishers and Distributors, Delhi.
3. Ghosh A. and Ledwich G., *Power Quality Enhancement using Custom Power Devices* Kluwer Academic Publishers.
4. Mathur R.M. and Verma R.K., *Thyristor based FACTS controllers for Electrical Transmission Systems*, IEEE Press.
5. Bollen M.H.J., *Understanding Power Quality and Voltage Sag* , IEEE Press.
6. Padiyar K.R., *FACTS Controllers in Power Transmission and Distribution* New Age International Publisher, 2007.
7. Miller T.J.E., *Reactive Power Control in Electric Systems* , John Wiley.

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EEPS-103 POWER SYSTEM QUALITY AND ASSESSMENT

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

INTRODUCTION: Power quality-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN -C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, Elecgtromagnetic Comatibility (EMC) standards and recommended practices.

POWER ASSESSMENT UNDER WAVEFORM DISTORTION: Introduction, single phase definitions, three phase definitions, illustrative examples.

WAVEFORM PROCESSING TECHNIQUES: Fundamental frequency characterization, Fourier analysis, Fast Fourier Transform, Window functions, Efficiency of Fast Fourier Transform (FFT) algorithms, alternative transforms, wavelet transform, Hartely transform, Automation of disturbance recognition.

POWER QUALITY MONITORING: Introduction, transducers, Current Transformer (CT), Potential Transformer (PT), power quality instrumentation, Harmonic monitoring, event recording, flicker monitoring, assessment of voltage and current unbalance, examples of application

HARMONIC DISTORTION AND MITIGATION: Introduction, direct harmonic analysis, incorporation of harmonic voltage sources, derivation of network harmonic impedances, solution by direct injection, Representation of individual power system components, implementation of harmonic analysis, post processing and display of results, Harmonic resonance, Impedance Scan Analysis-Active Power Factor Corrected Single Phase Front End, introduction to three Phase APFC and Control Techniques,

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

BOOKS RECOMMENDED:

1. Heydt G.T.,*Electric Power Quality*, Stars in a Circle Publishers, 1994.
2. Bollen Math H., *Understanding Power Quality Problems* .
3. Arrillaga J., *Power System Quality Assessment* , John Wiley, 2000.
4. Arrillaga J., Smith B.C., Watson N.R. and Wood A.R., *Power System Harmonic Analysis* , John Wiley, 1997.
5. Santoso Surya, Beaty H. Wayne, Dugan Roger C., McGranaghan Mark F., *Electrical Power System Quality*, McGraw Hills, 2002.

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EEPS-104 ADVANCED RELAYING AND PROTECTION

Internal Marks: 40
External Marks: 60
Total Marks: 100

L T P
3 1 0

PROTECTIVE RELAYING: Relay terminology, Definitions, Classification, electromechanical, static and digital-numerical relays. Design-factors affecting performance of a protection scheme for various faults, Instrument transformers for protection.

RELAY SCHEMATICS AND ANALYSIS: Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types- Characteristics.

PROTECTION OF POWER SYSTEM EQUIPMENTS: Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes.

SYSTEM GROUNDING: Ground faults and protection; Load shedding and frequency relaying; Out of step relaying; Re-closing and synchronizing.

BASIC ELEMENTS OF DIGITAL PROTECTION: Digital signal processing – Digital filtering in protection relay – digital data transmission – Numeric relay hardware – relay algorithm – distance relays – direction comparison relays – differential relays – software considerations – numeric relay testing –concept of modern coordinated control system.

INTEGRATED AND MULTIFUNCTION PROTECTION SCHEMES: SCADA based protection systems, Testing of Relays.

BOOKS RECOMMENDED:

1. John A T and Salman A K, *Digital protection for power systems-IEE power series-15* , Peter Peregrines Ltd,UK,1997
2. Mason C.R., *The art and science of protective relaying,* John Wiley &sons, 2002
3. Reimert Donald, *Protective relaying for power generation systems* , Taylor & Francis-CRC press 2006
4. Gerhard Ziegler, *Numerical distance protection*, Siemens, 2nd ed, 2006
5. Warrington A.R., *Protective Relays*, Vol .1&2, Chapman and Hall, 1973
6. T S.Madhav Rao, *Power system protection static relays with microprocessor applications* , Tata McGraw Hill Publication, 1994
8. Badri Ram , D.N. Vishwakarma, *Power system protection and switch gear* , Tata McGraw Hill, 2001
9. Blackburn, J. Lewis , *Protective Relaying, Principles and Applications* , Marcel Dekker, Inc., 1986.
10. Anderson, P.M, *Power System Protection*, McGraw-Hill, 1999
11. Singh L.P., *Digital Protection, Protective Relaying from Electromechanical to Microprocessor* , John Wiley & Sons, 1994

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EEPS-201 POWER SYSTEM OPERATION AND CONTROL

Internal Marks: 40
External Marks: 60
Total Marks: 100

L	T	P
3	1	0

INTRODUCTION: Characteristics of power generation units(thermal, nuclear, hydro, pumped hydro), variation in thermal unit characteristics with multiple valves, Economic dispatch with and without line losses, lambda iteration method, gradient method, Economic dispatch without line losses, economic dispatch with line losses, lambda iteration method, gradient method, Newton's method, base point and participation factors.

TRANSMISSION LOSSES: Coordination equations, incremental losses, penalty factors, B matrix loss formula (without derivation), methods of calculating penalty factors.

UNIT COMMITMENT: constraints in unit commitment, priority list method, Dynamic programming method and Lagrange relaxation methods.

HYDRO THERMAL CO-ORDINATION: Introduction to long range and short range hydro scheduling, Types of short range scheduling problem, Scheduling energy. The short term hydro-thermal scheduling problems and its solution by Lambda -Gamma iteration method and gradient method

GENERATION WITH LIMITED ENERGY SUPPLY: take or pay fuel supply contract, composite generation production cost function, gradient search techniques.

OPTIMAL POWER FLOW FORMULATION: gradient and Newton method, linear programming methods.

AUTOMATIC VOLTAGE REGULATOR: load frequency control, single area system, multi-area system, tie line control.

BOOKS RECOMMENDED:

1. Kothari D.P. and Dhillon J.S., *Power System Optimization*, Prentice-Hall of India Pvt. Ltd. New Delhi
2. G L.K .Kirchmayer, *Economic Operation of Power Systems* , John Willey & Sons,N.Y.
3. Wood A.J, Wollenberg B.F , *Power generation operation and control.*
4. Kothari D.P. and Nagrath I.J., *Modern Power System Analysis* ,Tata Mc Graw-Hill Publishing Company Ltd., New Delhi

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EEPS-202 POWER SYSTEM RESTRUCTURING AND DEREGULATION

Internal Marks: 40
External Marks: 60
Total Marks: 100

L T P
3 1 0

INTRODUCTION: Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.

POWER SYSTEM RESTRUCTURING An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.

DEREGULATION OF POWER SECTOR : Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing.

OPEN ACCESS SAME TIME INFORMATION SYSTEM (OASIS): Introduction, structure, functionality, implementation, posting of information, uses.

CONGESTION MANAGEMENT: Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC).

DISTRIBUTED GENERATION ON POWER QUALITY: Resurgence of distributed generation (DG), DG technology, Interface to utility System, Operating conflicts, DG on low voltage distribution networks, Siting DG, Interconnection standards

BOOKS RECOMMENDED:

1. Loi Lei Lai, *Power System Restructuring and Deregulation,* John Wiley & Sons Ltd.
2. Lorrin Philipson and H. Lee Willis, Marcel Dekker, *Understanding Electric Utilities and Deregulation*, New York, CRC Press, 2005.
3. Marija llic, Francisco Galiana and Lestor Fink , *Power System Restructuring Engineering & Economics*, Kulwer Academic Publisher, USA-2000.
4. Santoso Surya, Beaty H. Wayne, Dugan Roger C., McGranaghan Mark F., *Electrical Power System Quality*, McGraw Hills, 2002.

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EEPS-203 POWER SYSTEM DYNAMICS & STABILITY

Internal Marks: 40 | **L T P**
External Marks: 60 | **3 1 0**
Total Marks: 100

OVERVIEW: Angular Stability, Transient stability, steady state stability, dynamic stability, Small Signal, Voltage Stability

MODELING OF POWER SYSTEM COMPONENTS: Generators (Non-linear and linear models using d-q transformation, power capability curve); Excitation System (IEEE standard models); Turbine and Speed governing System; Loads (Induction motors and composite loads);

TRANSIENT STABILITY ANALYSIS Single Machine - Infinite Bus System; Equal Area Criterion; Multi-machine Stability; Network Reduction and Numerical Integration Methods; Methods of Improvement

SMALL SIGNAL STABILITY ANALYSIS Eigen Value and Participation Factor Analysis; Single machine - Infinite Bus and Multimachine Simulation; Effect of Excitation System and AVR; Improvement of Damping - Power System Stabilizer and SVS supplementary controls.

SUB SYNCHRONOUS OSCILLATIONS Sub Synchronous Resonance (SSR) Phenomenon; Counter measures to SSR problems

VOLTAGE STABILITY: P-V and Q-V curves, Impact of Load and Tap-changer Dynamics; Static Analysis, Sensitivity and Continuation Methods; Dynamic Simulation, Introduction to Bifurcation Analysis; Proximity Indices, Methods to enhance Stability Margin.

BOOKS RECOMMENDED:

1. Kundur P, *Power System Stability and Control* , McGraw Hill.
2. Taylor C.W., *Power System Voltage Stability*, McGraw Hill.
3. Anderson P.M. and Foud A. A., *Power System Control and Stability* , IEEE Press.
4. Kimbark E., *Power System Stability*, Vol. I, II & III, IEEE Press.

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EEPS-204A INDUSTRIAL DRIVES & AUTOMATIONS

Internal Marks: 40
External Marks: 60
Total Marks: 100

L	T	P
3	1	0

INTRODUCTION: Definition, Types of loads, steady state & transient stability of Drive, state of art of power electronics and drives, selection of motor rating.

D.C. DRIVES: Review of braking and speed control of D.C. motors, multi-quadrant operation, loss minimization in adjustable speed drives. Mathematical modeling of dc drives, stability analysis, modern control techniques: variable structure, adaptive control.

INDUCTION MOTOR DRIVES: Review of braking and speed control of induction motors. Constant V/F, constant air gap flux, controlled voltage, controlled current and controlled slip operation. Vector control, Mathematical modeling of induction motor drives, transient response and stability analysis Introduction to cycloconverter fed induction motor drive.

SYNCHRONOUS MOTOR DRIVES: Adjustable frequency operation, voltage fed drive, current fed self-controlled drive.

AUTOMATION USING DRIVES: Introduction, various components of automation, different sensors used in automation, PLC introduction and ladder programming, industrial application of automation, sensor less vector control and DTC drive, Recent trends in automation and case studies.

BOOKS RECOMMENDED:

1. Dubey G.K., *Power Semiconductor Controlled Drive*, Prentice Hall, New Jersey.
2. Sen P.C., *Thyristor Controlled DC Drives*, Wiley, New York.
3. Murphy J.M.D. and Turnbull F.G., *Power Electronics Control of AC Motors*, Franklin Book Co.
4. Bose B.K., *Power Electronics and AC Drives*, Prentice Hall, New Jersey.
5. Bose B.K.,*Power Electronics and Variable Frequency Drives-Technology and applicqtions* IEEE Press.

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EEPS-204B ADVANCED POWER ELECTRONICS

Internal Marks: 40
External Marks: 60
Total Marks: 100

L T P
3 1 0

REVIEW OF SEMICONDUCTOR DEVICES: Conduction Process in semiconductors, pn Junction, Charge control description, Avalanche breakdown, Power diodes, Thyristors, Gate Turn Off thyristor (GTO), VI characteristics, Dynamic characteristics, ratings, protection, heat transfer by conduction, radiation and convection, heat sink design, driving circuits.

POWER MOSFET AND IGBT: Basic structur e, I-V Characteristic, Physics of device operation, switching characteristics, operating limitation and safe operating area.

EMERGING DEVICES AND CIRCUITS: Power junction Field effect transistor (FET), Integrated Gate-Commutated Thyristor (IGCT), Field Control Thyristor, Metal oxide semiconductor (MOS) Control Thyristor etc. Power ICs, New semiconductor materials.

SNUBBER CIRCUITS: Types of Snubber circuits, needs of Snubber circuit with diode, thyristor and transistors, Turn-off Snubber, over voltage snubber, turn on snubber, Snubber for bridge circuit configurations, GTO Snubber circuit.

GATE AND BASIC DRIVE CIRCUITS: Design Consideration, De-coupled drive circuits, Electrically isolated drive circuits, cascade connected drive circuits, Power device protection in drive circuits, circuit layout considerations.

BOOKS RECOMMENDED:

1. Mohan, Undeland and Robbins, *Power electronics: converters, Applications and Design* , John Wiley and Sons.
2. Rashid M.H., *Power Electronics Handbook*, Elsevier Press (Academic Press Series).
3. Finney D., *The Power Thyristor and its Applications* , McGraw Hill, New York.
4. Lander C. W. *Power Electronics*, McGraw Hill Book Co., U.K .
5. Rashid M.H., *Power Electronics* - Circuits, Devices and Applications, PHI, India.

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Punjab Technical University, PITK M. Tech Electrical Engineering (Power System) Batch 2015

EEPS-204 C : DISTRIBUTION AUTOMATION

Internal Marks:40
External Marks:60
Total Marks:100

L	T	P
3	1	0

1. **DISTRIBUTION AUTOMATION AND THE UTILITY SYSYEM:** Introduction to distribution automation (DA), Control system interfaces, control and data requirements, centralized Vs decentralized control, DA system, DA hardware, DAS software.
2. **DISTRBUTION AUTOMATION FUNCTIONS:** DA capabilities, Automation system computer facilities, management process, information management, system reliability management, system efficient management, voltage management, Load management.
3. **COMMUNICATION SYSTEMS FOR DA:** DA communication requirements, Communication reliability, cost effectiveness, data rate requirements, twoway capability, ability to communicate during outages and faults, ease of operation and maintenance.
4. **TECHNICAL BENEFITS:** DA benefit categories, Capital deferred savings, operation and maintenance savings, interruptions related savings, customer related saving, operational savings, improved operations.
5. **ECONOMIC EVALUATION METHODS:** development and evaluation of alternate plans.

BOOKS RECOMMENDED:

1. IEEE Tutorial Course Distribution Automation
2. IEEE working group on Distribution Automation
3. Control and Automation of Electric Distribution System, James, Northcote-Green Robert Wilson, CRC Press

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EEPS-204D REAL TIME INSTRUMENTATION

Internal Marks:	**40**	**L**	**T**	**P**
External Marks:	**60**	**3**	**1**	**0**
Total Marks:	**100**			

INTRODUCTION: Static and Dynamic characteristics, Error analysis; transducers and sensors; their characteristics and parameters; role of instrumentation in monitoring, control and industrial automation.

SIGNAL CONDITIONING: Amplifiers, multiplexers and dividers, timer multiplexers, Signal converters, ADC and DAC, Signal conditioning, digital signal conditioning, transmission of digital signals, Telemetry methods and errors, PLCC, AM, FM, PAM, PWM, PCM Techniques.

DATA ACQUISITION SYSTEM: Role of dedicated computers, analog and digital control, computer systems for real time applications, distributed and supervisory control, SCADA and its organization and structure, centralized, hierarchical and decentralized control schemes, man machine interface, energy management system.

REAL TIME CONTROL APPLICATIONS: Instrumentation and conditioning of drive signals, data acquisition of drive system, energy management system for AGC, VAR Control, state estimation, security monitoring, economic dispatch, on line load management. Power system digital relaying, Power plant instrumentation.

BOOKS RECOMMENDED:

1. Torsten Cegrell, *Power System Control Technology*, PHI, India.
2. Kusic C. L., *Computer Aided Power System Analysis*, TMH, New Delhi.
3. Wood A. J. and Wollenberg B., *Power generation operation and control*, John Wiley.
4. Cerni R.H and Foster L.E., *Instrumentation for Engineering Management*, John Wiley and Sons.

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EEPS-204E MICROPROCESSOR AND MICROCONTROLLERS

Internal Marks: 40
External Marks: 60
Total Marks: 100

L T P
3 1 0

MICROPROCESSOR: 8086 Internal Architecture, Addressing modes, program development steps, 8086 instruction set, Assembler directives, Assembly language, program development tools.

PROGRAMMING OF 8086: Simple sequence programs, jumps, flags, conditional Jumps, IF-THEN, IF-THEN-ELSE, Multiple IF-THEN-ELSE, WHILE-DO, REPEAT-UNTIL, Instruction Timing and delay loops, strings, procedures, Macros.

PERIPHERAL INTERFACING: Parallel versus serial transmission, synchronous and asynchronous serial data transmission. Interfacing or hexadecimal keyboard and display unit, parallel, serial interface Standards.

MICROPROCESSOR APPLICATIONS TO POWER ENGINEERING: Protective Relaying: over-current, impedance, MHO, reactance, bi-directional relays.

MEASUREMENTS: Frequency, power angle & power factor, Voltage and Current, kVA, kW, and kVAR, maximum demand. Resistance, Reactance, Temperature Controls.

Microcontroller: PICi8 family Microcontroller, architecture, Addressing Modes, Timers, Counters, Interrupts, Serial Communication, Instruction Set and Programming Concepts and applications to Electric Drive Systems

BOOKS RECOMMENDED:

1. Rafiquzzaman, *M. Theory & Applications*, Prentice Hall (India) Publications 1993.
2. Ram B, *Fundamentals of Microprocessors and Microcomputers* , Dhanpat Rai and Sons,
3. Hall, Douglas V. *Microprocessors and interfacing: Programming and Hardware* , Tata McGraw Hill
4. Brey, Barry B., *The INTEL Microprocessors 8086/88, 80186, 286, 386, 486, Pentium Pro Processors, Architecture, Programming and Interfacing* , 4th Edition, Prentice Hall (India)
5. Ray A.K. and Bhurchandi K.M., *Advanced Microprocessors and Peripherals* , Tata McGraw Hill.
6. Mazidi M.A. et. al. *The PIC- Micro-controller & Embedded Systems,* Pearson Publication
7. Gaonkar R. S., *Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC*, Thomson learning

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Punjab Technical University, PITK M. Tech Electrical Engineering (Power System) Batch 2015

EEPS-205 A: INTELLECTUAL PROPERTY RIGHTS

Internal Marks:40
External Marks:60
Total Marks:100

L	T	P
3	1	0

1. **OVERVIEW OF INTELLECTUAL PROPERTY:** Introduction and the need for intellectual property right (IPR) – Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design – Genetic Resources and Traditional Knowledge – Trade Secret – IPR in India :Genesis and development – IPR in abroad – Major International Instruments concerning Intellectual Property Rights.
2. **PATENTS:** Patents - Elements of Patentability: Novelty, Non Obviousness, (Inventive Steps), Industrial Application - Non - Patentable Subject, Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and licence, Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties – Patent office and Appellate Board.
3. **COPYRIGHTS:** Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound, recordings - Registration Procedure, Term of protection, Ownership, of copyright, Assignment and licence of copyright - Infringement, Remedies & Penalties – Related Rights - Distinction between related rights and copyrights.

BOOKS RECOMMENDED:

1. Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.

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EEPS-205B ORGANIZATION AND FINANCE IN POWER SECTOR

Internal Marks: 40	**L T P**
External Marks: 60	**3 1 0**
Total Marks: 100	

MANAGEMENT AND ITS GOALS: Organization and Management; The manage ment process; Managerial skills and Managerial performance; Policy and Objectives of a Power Utility; The Goal of Firm.

UTILITY FINANCIAL ACCOUNTING: Balance Sheet, Income Statements and Cash Report; Depreciation; Interest charges during construction; Financial Statement Analysis.

INVESTMENT PROPOSAL: Interest and compounding; Measure of price - public versus private perspective; Economic evaluation of investment proposal; Internal Rate of return, Pay-Back Period

LEVELIZED COSTS OF GENERATION: Generating system costs; Basic concept of cost levelization; Levelized bus bar cost.

ELECTRICITY TARIFFS: Traditional Approach; Long-run Marginal costs; General Principles of Tariff Construction; Objectives of tariff.

UTILITY ORGANIZATION: Functional structure; Divisional Structure; Matrix structure; Hybrid structure.

INDUSTRY STATUS AND TRENDS: Main concerns of electric utilities; Performance of electric utilities; Power Sector changes; Dynamic, spot and real time pricing; Regulatory aspects - towards deregulation; System Planning under Evolving Utility Structures Computerized Management Game.

BOOKS RECOMMENDED:

1. Bartol K. M. and David C.,*Management* , Martin McGraw-Hill, INC.
2. Bartol K. M. and David C., *Management*, Martin McGraw-Hill, INC.
3. Weston J.F., *Brigham Essential of Managerial* Finance, Dryden Press.
4. Stoll, *Least-Cost Electric Utility Planning* , John Wiley.
5. Stickney C.P. and Weil R.L., *Financial Accounting*, Dryden Press.
6. Berrie T.W., *Electricity Economics and Planning* , IEE Power Series.
7. Levy H. and Sarnat M., *Capital Investment and Financial Decisions* , Prentice Hall.

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EEPS-205C POWER SYSTEM PLANNING

Internal Marks: 40	**L T P**
External Marks: 60	**3 1 0**
Total Marks: 100	

INTRODUCTION: Power System planning, objective, stages in planning and design, Key indices of power system reliability and their calculations, Linkage between reliability and capacity planning.

GENERATING SYSTEM CAPABILITY PLANNING: Probabilistic models of generating units, growth rate, Rate of generation capacity, Outage performance and system evaluation of loss of load and loss of energy indices, Power supply availability assessment.

INTERCONNECTED SYSTEMS: Multi area reliability analysis, Power pool operation and power exchange energy contracts, quantification of economic and reliability benefits of pool operation.

DEMAND/ENERGY FORECASTING: Electricity consumption pattern, Peak demand and energy forecasting by trend and economic projection methods.

POWER SYSTEM EXPANSION PLANNING Formulation of least cost optimization problem involving capital, operation and maintenance costs of candidate units of different types.

INVESTMENT PLANNING MODELS: Traditional generation expansion planning models, integrated resource planning models, production cost simulation models.

BOOKS RECOMMENDED:

1. Wallach Y., *Power System Planning* , McGraw Hill International.
2. Sullivan P., *Power System Planning*, McGraw Hill International.
3. Dasari, S., *Electric Power System Planning* , IBT Publishers, New Delhi.
4. Billinton R., *Power System Reliability Calculation* , MIT Press, USA.
5. Endreyni, *Reliability Modeling in Electric Power System* , John Wiley, New York.
6. McDonald J.R., *Modern Power system Planning* , McGraw Hill International.

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EEPS-205D LOAD AND ENERGY MANAGEMENT

Internal Marks: 40	**L T P**
External Marks: 60	**3 1 0**
Total Marks: 100	

LOAD FORECASTING: Classification and characterization of loads, Approaches to load forecasting, Forecasting methodology, Energy forecasting, Peak demand forecasting, Non-weather sensitive forecast and Weather sensitive forecast, Total forecast, Annual and monthly peak demand forecasts. Applications of state estimation to load forecasting.

LOAD MANAGEMENT: Introduction to Load management. Electric energy production and delivery system structure (EEPDS). Design alternatives for EEPD systems. Communication/control techniques for load management. Tariff structure and load management, principles of macro and microeconomics and energy pricing strategies, Assessing the impacts of load management.

ENERGY DEMAND FORECASTING: Static and dynamic analysis of energy demand, elements of energy demand forecasting, methodologies and models for energy demand forecasting, techno-economic approach in energy demand forecasting.

TRENDS AND CASE STUDIES: Energy management strategy, symbiotic relation between information, energy models and decision making, case studies like industrial energy forecasting, transportation energy forecasting, residential, commercial and agricultural energy forecasting.

BOOKS RECOMMENDED:

1. Martino J., *Technological Forecasting for Decision Making*, Elsevier Press, New York.
2. Gellings C.W. and Penn Well P.E., *Demand Forecasting in the Electric Utility Industry*, Fairmount Press.
3. Makridakis S., *Forecasting Methods and Applications*, Wiley.

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Punjab Technical University, PITK M. Tech Electrical Engineering (Power System) Batch 2015

EEPS-205 E: MODERN CONTROL THEORY

Internal Marks:40
External Marks:60
Total Marks:100

L	T	P
3	1	0

1. **INTRODUCTION:** Introduction to state and state variables – system representation in state variable form – transformations – Phase variable form – Canonical forms – Physical systems – Plant models – Representation using state function – Lagrange linearization.
2. **STATE TRANSITION:** State transition matrix – Properties and methods of valuation – Time response of linear systems – State diagrams – Resolvant matrix – Resolvant algorithm.
3. **DEFINITION AND CONCETS:** Criteria for controllability and observability – State variable feedback – Pole placement – Luenberg observer design.
4. **STABILITY**: Introduction – definition of stability – stability in the sense of Lyapunov – stability of linear systems – transient response – Behavior of estimation – stability of nonlinear systems – generation of Lyapunov functions.
5. **FORMULATION OF OPTIMAL CONTROL PROBLEM:** – method of calculus of variations – use of Hamiltonian method – Pontryagin"s minimum principle – Optimal control, problem – Hamilton – Jacobi approach – Continuous time linear state regulator matrix riccati equation – Methods of solution – State variable feedback design.

BOOKS RECOMMENDED:

1. Katsuhiko Ogata: Modern control Engineering, Prentice–Hall of India, 2010
2. 2. M. Gopal: Modern Control Systems Theory, Wiley Eastern Limited, New Delhi, 2005

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EEPS-301A INTELLIGENT TECHNIQUES AND APPLICATIONS

Internal Marks: 40
External Marks: 60
Total Marks: 100

L	T	P
3	1	0

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

FUZZY LOGIC: Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

ARTIFICIAL NEURAL NETWORK: Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

EVOLUTIONARY TECHNIQUES: Introduction and concepts of genetic algorithms and evolutionary programming, Differential Evolution

HYBRID SYSTEMS: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems

AI APPLICATIONS IN POWER SYSTEMS: Load flow, economic load dispatch, load forecasting, tr ansient stability and power system stabilizers

BOOKS RECOMMENDED:

1. Rajasekaran S. and Pai G.A.V ., *Neural Networks, Fuzzy Logic And Genetic Algorithm Synthesis and applications*, PHI New Delhi.
2. Lin C. and Lee G., *Neural Fuzzy Systems*, Prentice Hall International Inc.
3. Goldberg D.E.*Genetic Algorithms in Search Optimization and Machine Learning* Addition Wesley Co., New York.
4. Kosko B., *Neural Networks and Fuzzy Systems A dynamical systems approach to machine intelligence*, Prentice Hall of India.
5. Taylor C.W., *Power System stability* Mc-Graw Hill, New York.
6. Shivnandam S.N.,*Principle of soft computing,* Wiley.
7. RajshekaranS. and Pa G.A.V.i, *Neural Network , Fuzzy logic And Genetic Algorithm, PHI.*
8. Zurada Jack M., *"Introduction to Artificial Neural Network System"* JAICO Publication.
9. Ross Timothy J., *"Fuzzy logic with Engineering Applications"*, McGraw-Hills

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EEPS-301B OPTIMIZATION TECHNIQUES

Internal Marks:	**40**	**L**	**T**	**P**
External Marks:	**60**	**3**	**1**	**0**
Total Marks:	**100**			

INTRODUCTION TO OPTIMIZATION: Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engg. applications of optimization.

CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with in equality constr aints.

LINEAR PROGRAMMING: Standard form of linear programming ,Graphical solution, Simplex method, Twophase simplex method, Computer implementation of the simplex method, Duality theory.

TRANSPORTATION PROBLEM: North-West Corner rule, Least cost method, Vogel approximation method, testing for optimality.

NON-LINEAR PROGRAMMING:

One–Dimensional Minimization Methods : Unimodal function, Dichotomous search, Fibonacci search, Golden Section, Cubic interpolation method, Direct root, Newton Raphson Method

Unconstrained Multivariable Optimization Techniques: Random search method, Steepest descent method, Conjugate gradient method, Var iable metric method. Newton Raphson Method, Evolutionary search, Hooke-Jeeves Method, Simplex search Method

Constrained Optimization Techniques: Interior Penalty function method, Exterior penalty function method, Method of Multipliers, KKT Conditions

FURTHER TOPICS IN OPTIMIZATION: Critical path method (CPM), Program evaluation and review technique (PERT). Multiobjective Optimization Techniques, Weighting method, e-constraint method. Simulated annealing method

BOOKS RECOMMENDED:

1. Rao, S.S., *'Optimization : Theory and Application' Wiley Eastern Press, 2 nd edition 1984.*
2. Deb Kalyanmoy,.*Optimisation for Engineering Design-Algorithms and Examples.*, Prentice Hall India-1998
3. Taha,H.A.,*Operations Research -An Introduction,Prentice Hall of India,2003.*
4. Fox, R.L.,*'Optimization methods for Engineering Design', Addition Welsey, 1971.*
5. Ravindran A., Ragsdell K.M. and Reklaitis G.V. *Engineering Optimization: Methods And applications , Wiley, 2008*
6. *Godfrey C. Onwubolu , B. V. Babu , New optimization techniques in engineering , Springer, 2004*

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EEPS-301 C: ELECTRIC SMART GRID

Internal Marks:40
External Marks:60
Total Marks:100

L	T	P
3	1	0

1. **INTRODUCTION TO SMART GRID:** Introduction to Smart Grid - Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – Key Challenges for Smart Grid.
2. **SMART GRID ARCHITECTURE:** Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable Integration.
3. **TOOLS AND TECHNIQUES FOR SMART GRIDS:** Computational Techniques – Static and Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms – Artificial Intelligence techniques.
4. **COMMUNICATION TECHNOLOGIES AND SMART GRID:** Introduction to Communication Technology –Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS).

BOOKS RECOMMENDED:

1. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press, 2013
2. 2. Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2004.

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EEPS-301D EHVAC AND HVDC TRANSMISSION SYSTEM

Internal Marks: 40
External Marks: 60
Total Marks: 100

L	T	P
3	1	0

OVERVIEW: Comparison of EHV AC and DC transmission, description of DC transmission systems, modern trends in AC and DC transmission.

EHV AC SYSTEMS: Limitations of extra-long AC transmission, Voltage profile and voltage gradient of conductor, Electrostatic field of transmission line, Reactive Power planning and control, traveling and standing waves, EHV cable transmission system.

STATIC VAR SYSTEM: Reactive VAR requirements, Static VAR systems, SVC in power systems, design concepts and analysis for system dynamic performance, voltage support, damping and reactive support.

HVDC SYSTEM: Converter configurations and their characteristics, DC link control, converter control characteristics; Monopolar operation, converter with and without overlap, smoothing reactors, transients in DC line, converter faults and protection, HVDC Breakers.

CORONA AND INTERFERENCE: Corona and corona loss due to EHV AC and HVDC, Radio and TV interference due to EHV AC and HVDC systems, methods to reduce noise, radio and TV interference.

HARMONIC FILTERS: Generation of harmonics, design of AC filters, DC filters.

POWER FLOW ANALYSIS IN AC/DC SYSTEMS: Component models, solution of DC load flow, per unit system for DC quantities, solution techniques of AC-DC power flow equations, Parallel operation of HVDC/AC systems, Multi terminal systems.

BOOKS RECOMMENDED:

1. Padiyar K.R., *HVDC Power Transmission Systems*, Wiley Eastern Ltd., New Delhi.
2. Kimbark E., *Direct Current Transmission*, Vol-I, John-Wiley and sons, NY
3. Arrillaga J., *HVDC Transmission*, IEE Press, London.
4. Begamudre R.D., *EHV AC Transmission Engineering*, Wiley Eastern Press.
5. Arrillaga J. and Smith B.C., *AC-DC Power System Analysis*, IEE Press, London.

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EEPS-301E RENEWABLE ENERGY RESOURCES

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

ENERGY RESOURCES: Renewable energy sources, Environment, Energy and Global Climate Change energy parameters, cogeneration, rational use of energy, energy efficiency and conservation, distributed energy systems and dispersed generation, atmospheric aspects of electric energy generation, Impact of renewable energy generation on environment, GHG emissions from various energy sources, Electromagnetic Radiation from Extra High Voltage Overhead lines

SOLAR ENERGY: Solar Radiation and its Measurement, Solar Thermal Energy Collectors, Solar Thermal Energy Conversion Systems, Solar Photovoltaic System.

WIND ENERGY: Wind turbines and rotors, Wind Energy Extraction, Wind Characteristics, Power Density Duration Curve, Design of Wind Turbine Rotor, Design of Regulating System for Rotor, Wind Power Generation Curve, Sub-systems of a Horizontal Axis Wind Turbine Generator, Modes of Wind Power Generation, Estimation of Wind Energy Potential, Selection of Optimum Wind Energy Generator (WEG), Grid Interfacing of a Wind Farm, Methods of Grid Connection, Grid System and Properties, Capacity of Wind Farms for Penetration into Grid, Control System for Wind Farms, Economics of Wind Farms

GEOTHERMAL ENERGY: Structure of the Earth's Interior, Plate Tectonic Theory, Geothermal Sites, Geothermal Field, Geothermal Gradients, Geothermal Resources, Geothermal Power Generation, Geothermal Electric Power Plant, Geothermal-Preheat Hybrid with Conventional Plant

OCEAN ENERGY Development of a Tidal Power Scheme, Grid Interfacing of Tidal Power, Wave Energy, Mathematical Analysis of Wave Energy, Empirical Formulae on Wave Energy, Wave Energy Conversion, Principle of Wave Energy plant, Wave Energy Conversion Machines

FUEL CELLS: Principle of Operation of Fuel Cell, Fuel Processor, Fuel Cell Types, Energy Output of a Fuel Cell, Efficiency, and EMF of a Fuel Cell, Operating Characteristics of Fuel Cells, Thermal Efficiency of a Fuel Cell

HYDROGEN ENERGY SYSTEM: Hydrogen Production, Hydrogen Storage, Development of Hydrogen Cartridge, Gas Hydrate

HYBRID ENERGY SYSTEMS: Hybrid Systems AND ITS Types, Electric and Hybrid Electric Vehicles, Hydrogen-Powered-Electric Vehicles.

BOOKS RECOMMENDED:

1. Kothari DP, Singal KC and Ranjan Rakesh, *Renewable energy sources and emerging technologies* , 2nd ed, Prentice Hall (India)
2. G.D. Rai, *Non-Conventional Sources of Energy* , Khanna Publishers.
3. Bansal N.K., M. Kleemann, M. Heliss, *Renewable energy sources and conversion technology* , Tata McGraw Hill 1990.
4. Abbasi SA, Abbasi N, *Renewable energy sources andtheir environmental impact,* PHI, 2001
5. Mittal KM, *Renewable energy Systems,* Wheelar Publishing, New Delhi, 1997.
6. Mukherjee D, *Renewable energy Systems,* New Age International, New Delhi, 2004

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EEPS-302A HIGH VOLTAGE ENGINEERING AND TEST TECHNIQUES

Internal Marks: 40
External Marks: 60
Total Marks: 100

L T P
3 1 0

INTRODUCTION: Power Systems Development and High Voltage Engineering; Contents of High Voltage Engineering; Applications of High Voltage Technology.

TRAVELING WAVES: Transient and traveling waves; Effects of Line Terminations; Junction of several lines; Bewley Lattice Diagram; Traveling wave in transformer and generator.

LIGHTNING IN POWER SYSTEMS: Lightning formation; Lightning overvoltages (strike and backflashover) in power systems; Lightning overvoltages protection devices in power systems; Lightning protection system of high buildings.

SWITCHING OVER VOLTAGES: Types of internal overvoltages; The importance of switching overvoltages; Causes of various internal overvoltages; Control of switching overvoltages; EMTP and its applications.

ARRESTERS AND INSULATION COORDINATION: Surge arresters (MOA) and its performances; Voltage-Time Characteristics and coordination; Surge arresters selection and location in power systems; Principles of insulation coordination; Statistical and conventional insulation coordination.

HIGH VOLTAGE CABLES: Configuration and design features of high voltage cables; Testing of high voltage cables; Diagnostics of high voltage cables.

AIR AND SF6 BREAKDOWN: Fundamental aspects of air and SF6 breakdown, U -curve and gap factor; Sparkover characteristics; SF6 gas insulation performance.

GAS INSULATED SUBSTATION: Gas Insulated Substation (GIS) and its importance; Configuration and design features of GIS; Prospects of GIS.

HIGH VOLTAGE TEST OF ELECTRICAL APPARATUS: Nondestructive insulation testing; Destructive insulation testing: AC, DC, and Impulse testing of apparatus; New high voltage measurement technology; Safety in high voltage lab. Applications of high voltages technology in other area.

BOOKS RECOMMENDED:

1. Khalifa M., *High-Voltage Engineering*, Theory and Practice, Marcel Dekker, Inc.
2. Ryan H.M., *High Voltage Engineering and Testing* , IEE Press.
3. Gonen T., *Electric Power Distribution System Engineering* : Analysis and Design, McGraw Hill Book Co.

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EEPS-302B ENERGY EFFICIENT MACHINES

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

INTRODUCTION : Energy efficient machines, energy cost and two part tariff, energy conservation in industries and agriculture sector -a necessity, introduction to energy management and energy audit system. Review of induction motor characteristics.

ENERGY EFFICIENT MOTORS: Standard motor efficiency, energy efficient motor, efficiency determination methods, Direct Measurement method, Loss segregation method, Comparison, motor efficiency labeling, ener gy efficient motor standards.

POWER FACTOR: The power factor in sinusoidal systems, power factor improvement, power factor with nonlinear loads, Harmonics and the power f actor

APPLICATION OF ELECTRIC MOTORS: Varying duty applications, Voltage variation, Voltage Unbalance, Over motoring, Poly-phase induction motors supplied by adjustable frequency power supplies.

INDUCTION MOTORS AND ADJUSTABLE DRIVE SYSTEMS Energy Conservation, adjustable speed systems, Application of adjustable speed systems to fans, pumps and constant torque loads.

ECONOMICS OF ENERGY EFFICIENT MOTORS AND SYSTEMS: Motor life cycle, Direct Savings and pay back analysis, efficiency evaluation factor, present worth method with constant power costs, present worth method with increasing power costs, net present worth method.

BOOKS RECOMMENDED:

1. Andreas John C., *Energy efficient electric motors* , Marcel Dekker Inc. 1992.

2. Thuman Albert, *Introduction to Efficient Electric System Design* , The Fairmount Press Prentice Hall.

3. Tripathi S.C. , *Electric Energy Utilization and Conservation* , Tata McGraw-Hill 1991.

4. Belove Charles, *Handbook of Modem Electronics and Electrical Engineering* , John Wiley & Sons.

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EEPS-302C MODELING AND DYNAMICS OF ELECTRICAL MACHINES

Internal Marks:	**40**	**L**	**T**	**P**
External Marks:	**60**	**3**	**1**	**0**
Total Marks:	**100**			

INTRODUCTION: Challenges in computer simulations, Mechanics of simulation, solution techniques for time domain analysis, introduction of widely used circuit- oriented simulators like Pspice, MATLAB, PSIM, equation solvers, simulation of power electronics circuits and converters,

DYNAMIC CONDITIONS: Concept, constraints and considerations; modeling and performance simulation methods, concept of reference frame, generalized transformation, formulation of dynamic equations of a generalized machine in arbitrary reference frame.

D.C. MACHINES DYNAMICS: Ideal machine; dynamic equation; transfer function and block diagram; linear analysis of D.C. generators; effects of saturation; analysis and performance under disturbances. Switching and surge voltage transients in transformers.

INDUCTION MACHINES: Transients and dynamics; basic electro mechanical equations; linearized and non-linearized analysis; operation on harmonic supplies; unbalanced operation.

SYNCHRONOUS MACHINE TRANSIENTS: Coupled circuit viewpoint; approximate physical picture; equivalent circuit under transient conditions and its applications; synchronous motor operation with variable/fixed load torque and excitation; equal-area criterion for the study of transient stability.

BOOKS RECOMMENDED:

1. Krause P.C., *Electric Machinery*, McGraw Hill.
2. Kimbark E.W., *Power System Stability* Vol 3 Synchronous Machine, John Wiley and Sons.
3. Concordia C., *Synchronous machines*, Theory and Performance, John Wiley and Sons.
4. Adkins B. and Harley R. G., *The General theory of Alternating Current Machines* Chapman and Hall.
5. Ong Chee Mun, *Dynamic Simulation of Electric Machinery using MatLab and Simulink* , Pentice Hall (India), New Jersey

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EEPS-302D POWER SYSTEM TRANSIENTS

Internal Marks:	**40**	**L**	**T P**
External Marks:	**60**	**3**	**1 0**
Total Marks:	**100**		

ORIGIN AND NATURE OF TRANSIENTS AND SURGES: Surge parameters of plant. Equivalent circuit representations. Lumped and distributed circuit transients.

LINE ENERGIZATION AND DE-ENER GIZATION TRANSIENTS: Earth and earth wire effects. Current chopping in circuit breakers. Short line fault condition and its relation to circuit breaker duty. Trapped charge effects. Effect of source and source representation in short line fault studies. Control of transients.

LIGHTNING PHENOMENON Influence of tower footing resistance and earth resistance. Traveling waves in distributed parameter multi-conductor lines, parameters as a function of frequency. Simulation of surge diverters in transient analysis. Influence of pole opening and pole re-closing.

INSULATION CO-ORDINATION : Over voltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs, and metallic contacts.

COMMUNICATION LINKS:PLCC, Microwave, Telephone line, Satellite, Fibre optic. Requirements of various communication equipments used in power systems. Computer networking in power systems.

BOOKS RECOMMENDED:

1. Vanikov V.A., *Transients in Power System* , Mir Publications, Moscow.
2. Bewley; L.V., *Traveling Waves on Transmission Lines* , Dover Publications Inc., New York.
3. Arora Ravindera and Mosch Wolfgang, *High Voltage Insulation Engineering*, New Age International Publishers Limited.
4. Greenwood A., *Electrical Transients in Power Systems* , John Wiley & Sons,
5. Stallings William , *Data and Computer Communication* , PHI, 1994.
6. Gowar John ,*Optical Communications Systems*, PHI, 1993.
7. R.E. Collin ,*Foundations of Microwave Engineering* .
8. Theodore S. Rappaport, *Wireless communication, Principles and Practice* , IEEE Press; PTR 1996

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EEPS-302E POWER SYSTEM RELIABILITY

		L	T	P
Internal Marks:	**40**	**3**	**1**	**0**
External Marks:	**60**			
Total Marks:	**100**			

PROBABILITY AND RELIABILITY: Review of probability concepts, probability distributions, applications of binomial distribution to engineering problems, probability distribution in reliability evaluation, reliability indices, network modeling and evaluation of simple and complex networks, system reliability evaluation using probability distributions, frequency and load duration techniques, key indices of power system reliability and their calculations.

GENERATION SYSTEM RELIABILITY EVALUATION: Concept of loss of load probability (LOLP), Energy demand, EDNS (Energy Demand Not Served), Evaluation of these indices for isolated systems, generation system, reliability analysis using the frequency and duration techniques.

TRANSMISSION SYSTEM RELIABILITY EVALUATION: Evaluation of LOLP and EDNS, indices for an isolated transmission system, interconnected system reliability, bulk power system reliability.

DISTRIBUTION SYSTEM RELIABILITY EVALUATION: Reliability analysis of radial systems with Switching.

BOOKS RECOMMENDED:

1. Billinton R., *Power System Reliability Calculation* , MIT Press, USA.
2. Endreyni, *Reliability Modeling in Electric Power System* , John Wiley, New York

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