J.B. INSTITUTE OF ENGINEERING AND TECHNOLOGY
(UGC AUTONOMOUS)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.TECH - ELECTRICAL POWER SYSTEMS (EPS)
Choice Based Credit System (CBCS)

COURSE STRUCTURE - R-18

SEMESTER-I

Sl. No.	Code	Core/ Elective	Course Title	L	T	P	C
1.	GM21A	Core1	Advanced Power System Analysis	3	0	0	3
2.	GM21B	Core2	Flexible AC Transmission Systems	3	0	0	3
3.	GM21C GM21D GM21E	PE 1	1.Energy Auditing Conservation & Management 2.Smart-Grids 3.EHVAC Transmission	3	0	0	3
4.	GM21F GM21G GM21H	PE 2	1.Electrical Power Distribution System 2.Power System Dynamics& Stability 3.Distribution Automation	3	0	0	3
5.	GM11K	Core	Research Methodology and IPR	2	0	0	2
6.	GM21J	Lab1	Electrical Simulation Lab-1	0	0	4	2
7.	GM21K	Lab2	Power Systems Lab-1	0	0	4	2
8.	GM21L	Audit-I	Disaster Management	2	0	0	0
TOTAL CREDITS							**18**

SEMESTER-II

Sl. No.	Code	Core/ Elective	Course Title	L	T	P	C
1.	GM22A	Core3	Advanced Power System Protection	3	0	0	3
2.	GM22B	Core4	Power System Operation and Deregulation	3	0	0	3
3.	GM22C GM22D GM22E	PE 3	1.High Voltage Engineering 2.Power Quality 3. HVDC Transmission	3	0	0	3
4.	GM22F GM22G GM22H	PE 4	1.Voltage Stability 2. AI Techniques in Electrical Engineering 3. Reactive Power Compensation and Management	3	0	0	3
5.	GM22I		Mini Project with Seminar	0	0	4	2
6.	GM22J	Lab3	Electrical Simulation Lab-2	0	0	4	2
7.	GM22K	Lab4	Power Systems Lab-2	0	0	4	2
8.	GM22L	Audit-II	Value Education	2	0	0	0
TOTAL CREDITS							**18**

SEMESTER-III

Sl. No.	Code	Core/ Elective	Course Title	L	T	P	C
1.	GM23A GM23B GM23C	PE 5	1. Reliability Engineering 2. Modern Control Theory 3. Advanced Digital Signal Processing	3	0	0	3
2.	GM2OA GM2OB	OE	1. Renewable Energy Systems 2. Power Plant Engineering	3	0	0	3
3.	GM23D	Major Project	Phase-I Dissertation	0	0	20	10
TOTAL CREDITS							**16**

SEMESTER-IV

Sl. No.	Code	Core/ Elective	Course Title	L	T	P	C
1.	GM24A	Major Project	Phase-II Dissertation	0	0	32	16
TOTAL CREDITS							**16**

TOTAL CREDITS: 68

PE: Program Elective
OE: Open Elective

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M.Tech. EPS	**L**	**T**	**P**	**C**
I Year -I Semester	**30**		**0**	**3**

CORE1: ADVANCED POWER SYSTEM ANALYSIS

Pre-requisite: Computer Methods in Power Systems

Course Objectives

1. To model the power system under steady state operating condition.
2. To construct bus admittance and impedance matrices using numerical methods.
3. To solve Load Flow problem using Gauss seidel, N-R and FDLF methods.
1. To analyse single contingency and multiple contingencies using Z_{BUS} Method.
2. To examine short circuit analysis using Z_{BUS}.

Course Outcomes

Upon the completion of the subject, the student will be able to

1. Construct network bus admittance matrix usingsuccessive elimination, node elimination, and triangular factorization.
2. Construct network bus impedance matrix using Y_{BUS}, bus building algorithm and power invariant transformations with mutually coupled branches.
3. Solve Load Flow problem using Gauss seidel, N-R and FDLF methods.
4. Analyse single contingency and multiple contingencies using Z_{BUS}method.
5. Make use of Z_{BUS} for symmetrical and unsymmetrical fault calculations.

UNIT-I: Formation of Y_{BUS}:Admittance model and network calculations, Branch and node admittances, Mutually coupledbranches in Y_{BUS}, An equivalent admittance network, Modification of Y_{BUS}, Network incidence matrix and Y_{BUS}, Method of successive elimination, Node elimination, Triangular factorization, Sparsity and near optimal ordering.

UNIT-II: Formation of Z_{BUS}:Impedance model and network calculations, Bus admittance and impedance matrices,Thevenin's Theorem and Z_{BUS}, Algorithms for building Z_{BUS}modification of existing Z_{BUS},Calculation of Z_{BUS} elements from Y_{BUS}, Power invariant transformations, Mutually CoupledBranches in Z_{BUS}.

UNIT-III: Load Flow Analysis:Gauss Seidel method, N-R Method, Decoupled method, Fast decoupled method, Comparison between power flow solutions, DC load flow.

UNIT-IV: Contingency Analysis: Z_{BUS}method in Contingency Analysis, Adding and removing multiple lines, Piece-wise solution of interconnected Systems, Analysis of single contingencies, Analysis of multiple contingencies,Contingency analysis of DC Model, System reduction for contingency and fault studies.

UNIT-V: Fault Analysis: Symmetrical faults, Fault calculations using Z_{BUS}, Fault calculations using Z_{BUS}equivalent circuits, Selection of circuit breakers, Unsymmetrical faults, Problems on various typesof faults.

TEXT BOOKS:

1. Pai M A, "Computer Techniques in Power System Analysis", Tata McGraw-Hill Publishing Company Ltd., New Delhi, Second Edition, 2007.
2. HadiSaadat, "Power System Analysis", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.
3. John J. Grainger and W.D. Stevenson Jr., "Power System Analysis", Tata McGraw-Hill, Sixth reprint, 2010.
4. Nagrath I.J. and Kothari D.P., "Modern Power System Analysis", Tata McGraw-Hill, Fourth Edition,2011.

REFERENCE BOOKS:

1. C.A.Gross, "Power System Analysis," Wiley India, 2011.
2. Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill PublishingCompany Limited, New Delhi, Second Edition, 2012.
3. Kundur P., "Power System Stability and Control", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.

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M.Tech. EPS **L T P C**
I Year -I Semester **3 0 0 3**

CORE 2: FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

Prerequisite: Power Electronics and Power Systems-II

Course Objectives:

1. To understand the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits.
2. To recall the objectives of Shunt and Series compensation.
3. To explain control of STATCOM and SVC and their comparison and the regulation of STATCOM.
4. To analyze the functioning and control of GCSC, TSSC and TCSC.

Course Outcomes:

After the completion of the subject, the student will be able to:

1. Understand the basic concept and types of FACTS controllers.
2. Summarize the operation of voltage source and current source converters.
3. Explain the objectives of shunt compensation, applications of shunt controllers and methods of controllable VAR generation.
4. Demonstrate the applications of SVC and STATCOM.
5. Illustrate the basic concept and applications of series FACTS controllers.

UNIT-I: FACTS concepts:Transmission interconnections power flow in an AC system, Loading capability limits, Dynamicstability considerations,

Importance of controllable parameters, Basic types of FACTS controllers, Benefits of FACTS controllers.

UNIT-II: Voltage Source Converters:Single phase three phase full wave bridge converters, Transformer connections for 12 pulse 24and 48 pulse operation.
Three level voltage source converter, Pulse width modulation converter, Basic concept of current source converters, and Comparison of current source converters withvoltage source converters.

UNIT-III: Static Shunt Compensation:Objectives of shunt compensation, Mid-point voltage regulation voltage instability prevention, Improvement of transient stability,
Power oscillation damping, Methods of controllable VARgeneration, Variable impedance type static VAR generators, Switching converter type VARgenerators, Hybrid VAR generators.

UNIT-IV: SVC and STATCOM**:**The regulation and slope transfer function and dynamic performance,
Transient stability ehancement and power oscillation damping, Operating point control and summary of compensator control.

UNIT-V: Static Series Compensators**:**Concept of series capacitive compensation, Improvement of transient stability, Power oscillation damping and Functional requirements of GTO thyristor

controlled Series Capacitor (GSC),

Thyristor Switched Series Capacitor (TSSC) and Thyristor Controlled Series Capacitor (TCSC), Control schemes for GSC,TSSC and TCSC.

TEXT BOOKS:

1. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi, First Edition,2001.

2. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers forElectrical Transmission Systems", IEEE press and John Wiley & Sons, First Edition,2002.

REFERENCE BOOKS:

1. A.T.John, "Flexible AC Transmission System", Institution of Electrical andElectronic Engineers (IEEE), First Edition,1999.
2. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters inPower System", Kluwer Academic Publishers, First Edition,2004.
3. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New AgeInternationalPublishers, New Delhi, Reprint, 2008.

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M.Tech. EPS				
I Year -I Semester	**3**	**0**	**0**	**3**

PROGRAM ELECTIVE – 1:ENERGY AUDITING, CONSERVATION AND MANAGEMENT

Prerequisite: Electrical Distribution Systems

Course Objectives:

1. To know the necessity of conservation of energy.
2. To generalize the methods of energy management.
3. To illustrate the factors to increase the efficiency of electrical equipment.
4. To detect the benefits of carrying out energy audits.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Tell energy audit of industries.
2. Predict management of energy systems.
3. Sequence the methods of improving efficiency of electric motor.
4. Analyze the power factor and to design a good illumination system.
5. Determine pay back periods for energy saving equipment.

UNIT-I: Basic principles of energy audit: Energy audit- Definitions, Concept, Types of audit, Energy index, Cost index, Pie charts, Sankeydiagrams,
Load profiles, Energy conservation schemes- Energy audit of industries- Energy savingpotential, Energy audit of process industry, Thermal power station, Building energy audit.

UNIT-II: Energy management: Principles of energy management, Organizing energy management program, Initiating, Planning,Controlling,
Promoting, Monitoring, Reporting, Energy manger, Qualities and functions, Language,Questionnaire – Check list for top management.

UNIT-III: Energy efficient motors: Energy efficient motors, Factors affecting efficiency, 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: Power factor – Methods of improvement, Location of capacitors, Pf with non linear loads, Effect ofharmonics on power factor, Power factor motor controllers - Good lighting system design andpractice,
Lighting control , Lighting energy audit - Energy instruments- Wattmeter, Data loggers,Thermocouples, Pyrometers,Lux meters, Tongue testers,Application of PLC's.

UNIT-V: Economic aspects and analysis: Economics analysis-Depreciation methods, Time value of money, Rate Of return, Present worthmethod ,
Replacement analysis, Life cycle costing analysis- Energy efficient motors- Calculation ofsimple payback method, Net present worth method- Power factor correction, Lighting -Applications of life cycle costing analysis, Return on investment.

TEXT BOOKS:

1. W.R. Murphy& G. Mckay,"Energy Management" Butter worth, HeinemannPublications, Second Edition, 2009.
2. Paul o' Callaghan, "Energy Management", Tata Mc-Graw Hill Book Company-FirstEdition, 1998.
3. W.C.Turner, "Energy Management Hand Book", CRC Press, First Edition, 2004.

REFERENCE BOOKS:

1. John .C. Andreas, "Energy Efficient Electric Motors",CRC Press, Third Edition, 1992.
2. Great Britain, "Energy Management and Good Lighting Practice: Fuel Efficiency- Booklet Volume 12-EEO, 1989.

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M.Tech. EPS **L T P C**
I Year -I Semester **30 0 3**

PROGRAM ELECTIVE – 1: SMART GRID

Course Objectives:

3. The concepts of SCADA communication systems. Analyze the power factor and to design a good illumination system.
4. Integration of smart devices for substation automation.
5. The concepts of SCADA communication systems.
6. Description of Energy management systems and framework.
7. Exposure on Distribution automation and management systems.

Course Outcomes:

At the end of the course,the student will be able to

8. Apply the concepts of smart grid architecture, dynamic energy systems, energy port in real time applications Integration of smart devices for substation automation.
9. Apply smart grid policies and programs to encourage end – use energy efficiency.
10. Explore the SCADA communication systems.
11. Extend knowledge of substation automation functions and benefits of data warehousing.
12. Interpret the load forecasting and transmission operations and management in real time applications.
13. Integrate DMS framework and real time DMS applications.

UNIT–I: Introduction to smart grid- Electricity network-Local energy networks- Electric transportation- Lowcarbon central generation-Attributes of the smart grid- Alternate views of a smart grid.
Smart grid to evolve a perfect power system:Introduction- Overview of theperfect power system configurations- Device level power system- Building integrated powersystems- Distributed power systems- Fully integrated power system-Nodes of innovation.

UNIT–II: DC distribution and smart grid:AC vs DC sources-Benefits of and drives of DC power delivery systems-Powering equipment andappliances with DC-Data centers and information technology loads-Future neighbourhood-Potential future work and research.
Intelligrid architecture for the smart grid:Introduction- Launching intelligrid-Intelligrid today-
Smart grid vision based on the intelligrid architecture-Barriers and enablingtechnologies.

UNIT–III: Dynamic Energy Systems Concept:Smart energy efficient end use devices-Smart distributed energy resources-Advanced wholebuilding control systems- Integrated communications architecture-Energy management-Role oftechnology in demand response-
Current limitations to dynamic energy management-Distributedenergy resources-Overview of a dynamic energy management-Key characteristics of smartdevices- Key characteristics of advanced whole building control systems-Key characteristics ofdynamic energy management system.

UNIT–IV: Energy port as part of the smart grid:Concept of energy -Port, Generic features of the energy port.

Policies and programs to encourage end – Use energy efficiency:Policiesand programs in action - Multinational –National – State-City and corporate levels.
Market implementation:Framework-Factors influencing customer acceptance andresponse - program planning-monitoring and evaluation.

UNIT–V: Efficient Electric End – Use Technology Alternatives:Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating- hyper efficient appliances - Ductless residential heat pumps and air conditioners – Variablerefrigerant flow air conditioning- Heat pump water heating –
Hyper efficient residential appliances -Data center energy efficiency- LED street and area lighting - Industrial motors and drives -Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage -Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TEXT BOOKS:

1. Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response", CRC Press, 2009.
2. JanakaEkanayake, KithsiriLiyanage,Jianzhong.Wu, Akihiko.Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.

REFERENCE BOOKS:

1. James Momoh, "Smart Grid:Fundamentals of Design and Analysis"-Wiley, IEEE Press, First Edition, 2012.
2. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed and Efficient Energy", Academic Press, First Edition, 2011.
3. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press, First Edition, 2012.

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M.Tech. EPS				
I Year -I Semester	**30**		**0**	**3**

PROGRAM ELECTIVE –1: EHV AC TRANSMISSION

Prerequisite: Power Systems -II

Course objectives:

1. To identify the different aspects of Extra High Voltage A.C and D.C Transmission design and Analysis.
2. To understand the importance of modern developments of E.H.V and U.H.V transmission systems.
3. To demonstrate EHV ac transmission system components, protection and insulation level for over voltages.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. List the necessity of EHV AC transmission, choice of voltage for transmission, line losses and power handling capability.
2. Estimate the Statistical procedures for line designs, scientific and engineering principles in power systems.
3. Construct commercial transmission system.

UNIT- I:E.H.V.A.C: Transmission line trends and preliminary aspect standard transmission voltages –Estimation at line and ground parameters-

Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – Positive, negative and zero sequence impedance – Line Parameters for modes of propagation.

UNIT- II: Electrostatic field and voltage gradients – Calculations of electrostatic field of AC lines – Effect of high electrostatic field on biological organisms and human beings –
Surface voltage gradients and maximum gradients of actual transmission lines – Voltage gradients on sub conductor.

UNIT- III: Electrostatic induction in unenergized lines – Measurement of field and voltage gradients for three phase single and double circuit lines – Unenergized lines.
Power frequency voltage control and over-voltages in EHV lines: No load voltage – Charging currents at power frequency-Voltage control – Shunt and series compensation – Static VAR compensation.

UNIT - IV: Corona in E.H.V. lines – Corona loss formulae- Attenuation of traveling waves due to corona – Audio noise due to corona, its generation, Characteristic and limits.
Measurements of audio noise radio interference due to corona - Properties of radio noise – Frequency spectrum of RI fields –Measurements of RI and RIV.

UNIT- V: Design of EHV lines based on steady state and transient limits –
EHV cables and their characteristics.

TEXT BOOKS:

1. R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd, Revised Third Edition, 2006.
2. S. Rao, "HVAC and DC Transmission", Khanna Publishers, New Delhi, Third Edition.
3. Subir Ray, "An Introduction to High Voltage Engineering", Prentice Hall of India Private Limited, Seventh Printing, Second Edition, 2013.

REFERENCE BOOKS:

1. Luces M. Fualkenberry, Walter Coffer, "Electrical Power Distribution and Transmission", Pearson Education, Third Edition, 2008.
2. B.R.Gupta, "Power System Analysis and Design", A H Wheeler Publishing Company Limited, third Edition, 1998.
3. S.N. Singh, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd, New Delhi, second Edition, 2011.
4. Edison, "EHV Transmission line"- Electric Institution (GEC 1968).
5. Kimbark E.W. "Direct Current Transmission", Wiley Interscience,Vol.I, Wiley, 1971.

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	L	T	P	C
M.Tech. EPS				
I Year -I Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 2: ELECTRIC POWER DISTRIBUTION SYSTEM

Prerequisite: Electric Distribution Systems

Course Objectives:

1.Learning about power distribution system.
2.Learning of SCADA System.
3.Understanding distribution automation.

Course Outcomes:

Students will be able to:

1. Knowledge of power distribution system.
2. Study of distribution automation and its application in practice.
3. To learn SCADA system.

UNIT-I: Distribution of power, Management, Power loads,
Load forecasting short-term & long- term, power system loading, Technological forecasting.

UNIT-II: Advantages of Distribution Management System (D.M.S.) Distribution automation: Definition,
Restoration / Reconfiguration of distribution network, Different methods and constraints power factor correction.

UNIT-III: Interconnection of distribution, control & communication systems, Remote metering, Automatic meter reading and its implementation.
SCADA: Introduction, Block Diagram, SCADA applied to distribution automation, Common functions of SCADA, Advantages of distribution automation through SCADA.

UNIT-IV: Calculation of optimum number of switches, Capacitors, Optimum switching device placement in radial, Distribution systems,
Sectionalizing switches – Types, Benefits, Bellman's optimality principle, Remote terminal units, Energy efficiency in electrical distribution &monitoring.

UNIT-V: Maintenance of automated distribution systems, Difficulties in implementing distribution-
Automation in actual practice, Urban/Rural distribution, Energy management, AI techniques applied to distribution automation.

TEXT BOOKS

1. A.S. Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., New Delhi, Sixth Edition, 2017.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical Power Distribution Automation", University Science Press, New Delhi, First Edition, 2010.

REFERENCE BOOKS:

1. Anthony J Panseni, “Electrical Distribution Engineering”, CRC Press, Third Edition, 2006
2. James Momoh, “Electric Power Distribution, Automation, Protection & Control”, CRC Press. First Edition, 2007.
3. TuranGonen, “Electric Power Distribution”, CRC Press. Third Edition, 2014.

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	L	T	P	C
M.Tech. EPS				
I Year -I Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 2: POWER SYSTEM DYNAMICSAND STABILITY

Pre-requisite: Computer Methods in Power Systems

Course objectives

1. To remember the dynamic characteristics of power system equipment.
2. To recognize dynamic performance of power systems.
3. To illustrate the system stability and controls.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Choose the fundamental dynamic behaviour and controls of power systems to perform basic stability analysis.

2. Comprehend concepts in modelingof excitation systems.

3. Interpret results of system stability studies.

4. Analyzethe concepts of dynamic stability, voltage stability and the factors affecting these voltage instability and voltage collapse.

UNIT-I: Basic concepts:Power system stability status of operation and system security, System dynamics problems,
System model analysis of steadystate stability and transient stability, Simplified representation of excitationcontrol.

UNIT-II: Modeling of excitation systems:Excitation systemrequirements, Elements of an excitation system, Types of excitation systems - Type-2 system: Rotating rectifier system, Type-3 system: Static with terminal potential and current supplies, Type-4 system: Non – continuous acting - Block diagram representation – State space modeling equations of these types.

UNIT-III: Dynamic stability:Concept of Dynamic stability – Statespace model of one machine system connected to infinite bus –
Effect ofexcitation on Dynamic stability – Examination of dynamic stability by Routh'scriterion.

UNIT-IV: Voltage stability:Voltagestability – Voltage collapse, Voltage security, Physical relation indicatingdependence of voltage and reactive power flow,
Factors affecting voltageinstability and collapse – Previous case of voltage collapse incidences.

UNIT-V: Voltage stability analysis:PV curve-QV curve- Control of voltage instability,
Voltage stability analysis- Static & dynamic analysis-The continuation power flow analysis-Prevention of voltage collapse.

TEXT BOOKS:

1. K.R. Padiyar, "Power System Dynamics: Stability and Control"- B.S. Publications, 2nd Edition, 2002.
1. Kundur P., 'Power System Stability and Control, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.
2. Abhijit Chakrabarti, "Power System Dynamics and Simulation", PHI Publications, 1st Edition, 2013.

REFERENCE BOOKS:

1. P.M. Anderson and A.A. Fouad, "Power System Control and Stability", IEEE Presss,2nd Edition, 2002.
2. R. Ramanujam, "Power Systems Dynamics: Analysis and Simulation", PHI Publications, 1st Edition, 2010.
3. Harry G. Kwatny and Karen Miu-Miller, "Power System Dynamics and Control", Birkhauser Publications, 1st Edition, 2016.

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	L	T	P	C
M.Tech. EPS				
I Year -I Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 2: DISTRIBUTION AUTOMATION

Prerequisite: Electrical Distribution Systems

Course Objectives:

1. To list the distribution systems for load modeling.
2. To understand the design & working of substations.
3. To compute system protection.
4. To give a comprehensive idea on communication systems.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Find the transfer of electrical data in distribution system through digital communication.
2. Predict load forecasting and reliability in economic point of view.
3. Apply distribution automation objectives and SCADA.
4. To have a knowledge on management of different electrical parameters.

UNIT-I: Distribution automation and the utility system**:** Introduction to distribution automation (DA), Control system interfaces, Control and datarequirements,

Centralized vs decentralized control, DA System (DAS), DA hardware, DASsoftware.

UNIT-II: Distribution automation functions:DA capabilities, Automation system computer facilities, Management processes, Informationmanagement,
System reliability management, System efficiency management, Voltage management, Load management.

UNIT-III: Communication systems for DA:DA communication requirements, Communication reliability, Cost effectiveness, Data raterequirements, Two way capability, Ability to communicate during outages and faults, Ease ofoperation and maintenance, Conforming to the architecture of data flow.
Communication systems used in DA:Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio,
AM broadcast, FM SCA, VHFRadio, UHF Radio, Microwave satellite, Fiberoptics, Hybrid communication systems,Communication systems used in field tests.

UNIT-IV: Technical Benefits:DA benefit categories, Capital deferred savings, Operation and maintenance savings, Interruptionrelated savings, Customer related savings, Operational savings, improved operation, Functionbenefits, Potential benefits for functions, and function shared benefits,

Guidelines for formulationof estimating equations, Parameters required, Economic impact areas, Resources for determiningbenefits impact on distribution system, Integration of benefits into economic evaluation.

UNIT-V: Economic evaluation methods:Development and evaluation of alternate plans, Select study area, Select study period, Projectload growth, Develop alternatives, Calculate operating and

maintenance costs, Evaluatealternatives. Economic comparison of alternate plans, Classification of expenses and capitalexpenditures,

Comparison of revenue requirements of alternative plans, Book life and continuingplant analysis, Year by year revenue requirement analysis, Short term analysis, End of studyadjustment, Break even analysis, Sensitivity analysis computational aids.

TEXT BOOKS:

1. James. Northcote – Green Robert Wilson, "Control and Automation of Electrical Distribution Systems", CRC Press, First Edition, 2007.
2. Biswarup Das, "Power Distribution Automation", Institution of Engineering and Technology (IET) Publishers, Volume 2, 2016.
3. James A. Momoh, "Electric Power Distribution, Protection and Control", CRC Press, First Edition, 2007.

REFERENCE BOOKS:

1. Dr. M. K. Khedkar, Dr. G.M. Dhole, "Electric Power Distribution Automation", University Science press, First Edition, 2010.
2. Jan De Kock, Cobus Strauss, "Practical Power Distribution for Industry", Elsevier Publication, First Edition, 2004.

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M.Tech. EPS **L T P C**
I Year -I Semester **2 0 0 2**

CORE: RESEARCH METHODOLOGY AND IPR

Course Objectives:

1. To identify the research problem.
2. To investigate and interpret the solutions to the research problem.
3. To know the research ethics.
4. To understand patent rights and procedure for grants of patent.

Course Outcomes:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information and follow research ethics.
3. Understand that today's world is controlled by Computer, Information technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right (IPR) to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT-I: Meaning of research problem, Sources of research problem, Criteria characteristics of a good research problem, Errors in selecting a research problem,

Scope and objectives of research problem. Approaches of investigation of solutions for research problem, Data collection, Analysis, Interpretation, Necessary instrumentations

UNIT-II: Effective literature studies, Approaches, Analysis, Plagiarism, and Research ethics. Effective technical writing, How to write report paper,
Developing a research proposal, Format of research proposal, Presentation and assessment by a review committee

UNIT-III: Nature of Intellectual Property: Patents, Designs, Trade and copyright. Process of patenting and development:
Technological research, Innovation, Patenting, Development. International Scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

UNIT-IV: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.
Patent information and databases. Geographical Indications.

UNIT-V: New Developments in IPR: Administration of patent system. New developments in IPR; IPR of biological systems, Computer software etc.

Traditional knowledge, Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research Methodology: An Introduction for Science & Engineering Students'', Juta & Co. Ltd Publishers, Revised Second Edition, 2006.
2. Halbert, "Resisting Intellectual Property", Routledge, Taylor & Francis Ltd, First Edition, 2007.
3. C. R. Kothari, "Research Methodology: Methods and Techniques", New Age International Publications, Revised Second Edition, 2004.

REFERENCE BOOKS:

1. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners", British Library Publishers,Fourth Edition, 2014.
2. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age",Wolters Kluwer Law & Business Publishers, 2016.
3. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand Publications, First Edition, 2008.

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M.Tech. EPS	**L**	**T**	**P**	**C**
I Year -I Semester	**00**		**4**	**2**

LABORATORY – 1: ELECTRICAL SIMULATION LAB-1

Prerequisites: Power system analysis, power system reliability, voltage stability

Course Objectives:

4. Develop programs for power system analysis.
5. Design models for power systems and power electronics.
6. Develop programs of power system reliability and power electronics.

Course outcomes:

Upon the completion of the lab, the student will be able to

1. Understand/simulate/analyze power system analysis using software.
2. Models of power systems and power electronics.
3. Programs of power system reliability and power electronics.

List of the Experiments:

1. Simulation program for Y_{BUS} formation.
2. Simulation program for G-S load flow analysis.
3. Simulation program for N-R load flow analysis.
4. Simulation program for FDLF load flow analysis.
5. Simulation program for short circuit analysis.
6. Transient stability analysis for single machine connected to infinite bus by point by pointmethod.
7. Simulationprogram for generation system reliability analysis.
8. Simulationprogram for distribution system reliability analysis.
9. Simulink model for a single area load frequency problem and simulate the same.
10. Simulink model for a two area load frequency problem and simulate the same.

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UGC AUTONOMOUS

	L	T	P	C
M.Tech. EPS				
I Year -I Semester	**00**		**4**	**2**

LABORATORY – 2: POWER SYSTEMS LAB – I

Prerequisites: Power system, Photovoltaic Systems

Course Objectives:

11. To have knowledge on line – line and line to ground faults (L-G,L-L, L-L-G,L-L-L-G) and its analysis on synchronous machine.
12. To evaluate the behaviour of generator protection system.
13. To analyzepower angle characteristics of salient pole alternator
14. To understand the principles and concepts on various solar systems.

Course outcomes:

Upon the completion of the lab, the student will be able to

15. To have knowledge on short circuit analysis..
16. Ability to conduct experiments on synchronous machineto find the characteristics.
17. Able to understand the performance evaluation of various solar equipments.

List of Experiments:

1. Determination of sequence impedance of cylindrical rotor synchronous machine.
2. Single line to ground fault (L-G) analysis of cylindrical rotor synchronous machine.
3. Line to line fault (L-L) analysis of cylindrical rotor synchronous machine.
4. Double line to ground fault (L-L-G) analysis of cylindrical rotor synchronous machine.
5. Triple line to ground fault (L-L-L-G) analysis of cylindrical rotor synchronous machine.
6. Determination of sub-transient reactance of a salient pole synchronous machine.
7. Power angle characteristics of salient pole alternator.
8. Determine the effect of variation in tilt angle on solar PV module power.
9. Performance evaluation of a solar flat plate thermo syphon water heating system.
10. Operational characteristics of series and parallel combination of photo voltaic System.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

M.Tech. EPS	**L**	**T**	**P**	**C**
I Year -I Semester	**2**	**0**	**0**	**0**

AUDIT - I: DISASTER MANAGEMENT

Course Objectives:

1. Distinguish between disaster management and risk management.
2. Explain selected models of disaster management.
3. Describe the strategies for risk mitigation.
4. List activities needed for post-disaster management.

Course Outcomes:

After completing this session, student will be able to

5. Affirm the usefulness of integrating management principles in disaster mitigation work.
6. Distinguish between the different approaches needed to manage pre- during and post-disaster periods.
7. Explain the process of risk management.
8. Relate to risk transfer.

UNIT I: Introduction: Concepts and definitions: disaster, hazard, vulnerability,

risk, capacity, impact, prevention, mitigation.

UNIT II: Disasters: Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.);
manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.

UNIT III: Disaster impacts: Disaster impacts (environmental, physical, social, ecological, economical, political, etc.); health, psycho-social issues;
demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters.

UNIT IV: Disaster risk reduction: Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems,
Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

UNIT V: Disasters, environment and development: Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land-use changes, urbanization etc.),
sustainable and environmental-friendly recovery; reconstruction and development methods.

TEXT BOOKS:

1. H.K. Gupta, "Disaster Management",University Press, India, 2003.
2. Singh B.K., "Handbook of Disaster Management: techniques & Guidelines", Rajat Publications, 2008.
3. PradeepSahni,"Disaster Risk Reduction in South Asia", Prentice Hall, 2004.

REFERENCE BOOKS:

1. Ghosh G.K., "Disaster Management", APH Publishing Corporation, 2006.
2. R.B Singh, "Environmental Geography", Heritage Publishers, New Delhi, 1990.
3. R.R Singh, "Disaster Management", Rawat Publication, New Delhi, 2000.

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UGC AUTONOMOUS

	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**30**		**0**	**3**

CORE 3: ADVANCED POWER SYSTEM PROTECTION

Prerequisite: Switch Gear and Protection

Course Objectives:

1. To distinguish all kinds of circuit breakers and relays for protection of generators.
2. Transformers and feeder bus bars from over voltages and other hazards.
3. To generalize neutral grounding for overall protection.
4. To illustrate the phenomenon of over voltages and its classification.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Understand the basic function of a circuit breaker, all kinds of circuit breakers and differentiate fuse and circuit breakers under fault condition.
2. Describe the necessity for the protection of alternators, transformers and feeder bus bars from over voltages and other hazards.
3. Illustrate neutral grounding, and how over voltages can be generated and how system can be protected against lightning and switching transient over voltages with various protective schemes.
4. Identify operation and control of microprocessorbased relays.

UNIT-I: Staticrelays:Advantages of static relays, Basic construction of static relays, Level detectors, Replica impedance, Mixing circuits, General equation for two input phase and amplitude comparators, Duality between amplitude and phase comparators.
Amplitude comparators: Circulating current type and opposed voltage type, Rectifier bridge comparators, Direct and instantaneous comparators.

UNIT-II: Phase comparators:Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence, Integrating type, Rectifier and Vector product type, Phase comparators.
Static over current relays:Instantaneous overcurrent relay, Time overcurrent relays, Basicprinciples, Definite time and inverse definite time over-current relays.

UNIT-III: Static differential relays:Analysis of static differential relays, Static relay schemes, Duo bias transformer differentialprotection, Harmonic restraint relay.
Static distance relays:Static impedance-reactance, MHO and angle impedance relay, Samplingcomparator, Realization of reactance and MHO relay using sampling comparator.

UNIT-IV: Multi-input comparators:Conic section characteristics, Three input amplitude comparator, Hybrid comparator, switcheddistance schemes,
Poly phase distance schemes, phase fault scheme, three phase scheme, combined and ground fault scheme.

Power swings:Effect of power swings on the performance of distance relays, Power swinganalysis, Principle of out of step tripping and blocking relays, Effect of line length and sourceimpedance on distance relays.

UNIT-V: Microprocessor based protective relays:(Block diagram and flowchart approach only), Over current relays– Impedance relays – Directionalrelay-reactance relay.
Generalized mathematical expressions for distance relays-measurement ofresistance and reactance, MHO and offset MHO relays, Realization of MHO characteristics, Realization of offset MHO characteristics, Basic principle of Digital computer relaying.

TEXT BOOKS:

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear", Tata McGraw Hill Publication, New Delhi, 1995.
2. T.S.Madhava Rao, "Power system protection: Static relays", Tata McGraw Hill Publication, New Delhi, Second edition, 1989.

REFERENCE BOOKS:

1. BhaveshBhalja, R. P. Maheshearі, Nilesh G. Chothani, "Protection and Switchgear", OxfordUniversity Press, First Edition, 2011.
2. C. Christopoulos and A. Wright, "Electrical Power System Protection", Springer International, SecondEdition, 1999.
3. Russel Mason, "Art and Science of protective relays", Wiley – Blackwell Publications, FirstEdition, 1966.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
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	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**30**		**0**	**3**

CORE 4: POWER SYSTEM OPERATION AND DEREGULATION

Prerequisite: Power System Operation and Control

Course objectives:

1. To find OPF with security constraints.
2. To generalize modeling of load frequency control of a power system.
3. To compute reactive power control of a power system.
4. To apply the concept of deregulation and ATC.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Know the optimal scheduling of power plants.
2. Outline the modeling of turbine and generator.
3. Compute the steady state behavior of the power system for voltage and frequency fluctuations. Analyze ATC and the cost of transmission.

UNIT- I: Optimal power flow:Introduction- Solution to the optimal power flow-Gradient method-Newton's method-Linearsensitivity analysis-

Linear programming methods- Security constrained OPF-Interior pointalgorithm- Bus incremental costs.

UNIT-II: Power system security:Introduction –Factors affecting power system security-Contingency analysis-Detection of networkproblems-
Linear sensitivity analysis-AC power flow methods-Contingency selection-Concentricrelaxation-Bounding area method.

UNIT-III: State estimation in power systems:Introduction- Power system state estimation-Maximum likelihood, Weighted least squaresestimation-Matrix formulation- State estimation of AC network- State estimation by orthogonaldecomposition-
detection and identification of Bad measurements- Estimation of quantities notbeing measured-Network observability and pseudo measurements

UNIT-IV: Power system deregulation:Introduction- motivation for restructuring of power systems-Electricity market entities modelbenefitsof deregulation –
Terminology-Deregulation in Indian power sector-Operations in powermarkets-Power pools-Transmission networks and electricity markets.

UNIT-V: Available transfer capability:Introduction methods of determination of ATC -ATC calculation considering the effect ofcontingency analysis-
Transmission open access and pricing- Cost components of transmissionsystem- Transmission

pricing methods-Incremental cost based transmission pricing.

TEXT BOOKS:

1. P.Venkatesh. B.V.Manikandan, S.Charles Raja- A.Srinivasan, "Electrical Power Systems: Analysis, Security, Deregulation", PHI Publications, First Edition, 2012.
2. Loi, Lei, Lai, "Power System Restructuring and Deregulation", John Wiley Publications, First Edition, 2001.

REFERENCE BOOKS

1. A.J.Wood & B.F.Woollenberg, "Power Generation, Operation and Control", John Wiley Publications, Second Edition, 2006.
2. Geoffrey S Rothwell, Tomás Gómez, "Electricity Economics: Regulation and Deregulation",John Wiley Publications, First Edition, 2003.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**3**	**0**	**0**	**3**

PROGRAM ELECTIVE – 3: HIGH VOLTAGE ENGINEERING

Prerequisite: Power Systems and Electrical & Electronics Instrumentation

Course Objectives:

1. To distinguish the gaseous, liquid and solid dielectric behaviour under High Voltage (HV)
2. To understand the generation methods of high A.C, DC &impulse voltages required for various application.
3. To apply the measuring techniques of high A.C., D.C & impulse voltages and currents.
4. To identify the testing techniques for high voltage equipment.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Know conduction and breakdown will occur in gases, liquids and solids dielectrics, and different applications of the insulating materials in electrical power apparatus.
2. Explain the insulation testing of various components in power systems for different types of voltages, namely power frequency A.C, high frequency, switching or lightning impulses, for which generation of high voltages in laboratories is essential.
3. Interpret the necessity to measure the voltages and currents accurately, ensuring perfect safety to the personnel and equipment.
4. Detect the necessary condition for all the electrical equipment which are capable of withstanding the over voltages which met in service like natural causes lightning or system originated ones switching or power frequency transient voltage.

UNIT- I: Introduction to high voltage engineering:Electric field stresses, Gas / Vacuum as insulator, Liquid dielectrics, Solids and composites,Estimation and control of electric stress, Numerical methods for electric field computation,
Surge voltages their distribution and control, Applications of insulating materials in transformers,Rotating machines, Circuit breakers, Cable power capacitors and bushings.

UNIT- II: Break down in dielectric materials:Gases as insulating media, Collision process, Ionization process, Townsend's criteria ofbreakdown in gases, Paschen's law. Liquid as Insulator, pure and commercial liquids, Breakdownin pure and commercial liquids.
Intrinsic breakdown, Electromechanical breakdown, Thermalbreakdown, Breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, Soliddielectrics used in practice.

UNIT-III: Generation & measurement of high voltages & currents:Generation of high direct current voltages, Generation of high alternating voltages, Generationof impulse voltages, Generation of impulse currents,
Tripping and control of impulse generators.Measurement of high DC voltages, Measurement of high voltages alternating and impulse, Measurement of direct- alternating and impulse, Oscilloscope

for impulsevoltage and current measurements.

UNIT-IV: Over voltages & insulation co-ordination:Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges,

System faults and other abnormal conditions, Principles of insulation coordination on high voltage and extra high voltage power systems.

UNIT- V: Testing of materials & electrical apparatus:Measurement of D.C Resistivity, Measurement of dielectric constant and loss factor, Partialdischarge measurements. Testing of insulators and bushings,
Testing of isolators and circuitbreakers, testing of cables, Testing of transformers, Testing of surge arresters, and Radiointerference measurements.

TEXT BOOKS:

1. M.S.Naidu and V. Kamaraju,"High Voltage Engineering" Tata McGraw Hill Publications, Fifth Edition, 2013.
2. E.Kuffel, W.S.Zaengl, J.Kuffel, "High Voltage Engineering: Fundamentals", Elsevier, Second Edition, 2000.

REFERENCE BOOKS:

1. C.L.Wadhwa, "High Voltage Engineering", New Age Internationals (P) Limited, Third Edition, 1997.
2. RavindraArora, Wolfgang Mosch,"High Voltage and Electrical Insulation Engineering", Wiley Publications, 2011.
3. Mazen Abdel Salam, Hussein Anis,Ahdan El-Morshedy, RoshdyRadwan, "High Voltage Engineering, Theory and Practice"Marcel Dekker Publications, Second Edition, 2001.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

M.Tech. EPS	**L**	**T**	**P**	**C**
I Year -II Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 3: POWER QUALITY

Prerequisite: Power Systems and Power Electronics

Course Objectives:

1. To know different terms of power quality.
2. To Illustrate of voltage power quality issue - short and long interruption.
3. To construct study of characterization of voltage sag magnitude and three phase unbalancedvoltage sag.
4. To know the behavior of power electronics loads; induction motors, synchronous motor etcby the power quality issues.
5. To prepare mitigation of power quality issues by the VSI converters.

Course Outcomes:

Upon the completion of the subject, the student will be able to

1. Know the severity of power quality problems in distribution system.
2. Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage).
3. Compute the concept of improving the power quality to sensitive load by various mitigating custom power devices.

UNIT-I: Introduction:Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges,Harmonics, over voltages, spikes,

Voltage fluctuations, Transients, Interruption, overview ofpower quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT-II: Long & short interruptions:Long interruptions – Definition – Difference between failures, outage, Interruptions – causes of Longinterruptions – Origin of interruptions – Limits for the Interruption frequency – Limits for theinterruption duration – Costs of Interruption – Overview of reliability evaluation to power quality, Comparison of observations and reliability evaluation.
Short interruptions: Definition, Origin of short interruptions, Basic principle, Fuse saving, Voltagemagnitude events due to re-closing, Voltage during the interruption, Monitoring of shortinterruptions, Difference between medium and low voltage systems. Multiple events, Single phasetripping – Voltage and current during fault period, Voltage and current at post fault period,Stochastic prediction of short interruptions.

UNIT III: 1 & 3-Phase voltage sag characterization:Voltage sag – Definition, Causes of voltage sag, Voltage sag magnitude, and monitoring,Theoretical calculation of voltage sag magnitude, Voltage sag calculation in non-radial systems,
Meshed systems, and voltage sag duration.Three phase faults, Phase angle jumps, Magnitude and phase angle jumps for three phaseunbalanced sags, Load influence on voltage sags.

UNIT-IV: Power quality considerations in industrial power systems:Voltage sag – Equipment behavior of power electronic loads, Induction motors,

Synchronousmotors, computers, Consumer electronics, Adjustable speed AC drives and its operation.Mitigation of AC Drives, Adjustable speed DC drives and its operation, Mitigation methods of DCdrives.

UNIT-V: Mitigation of interruptions & voltage sags:Overview of mitigation methods from fault to trip, Reducing the number of faults, Reducing thefault clearing time changing the power system, Installing mitigation equipment, Improvingequipment immunity, Different events and mitigation methods. System equipment interface –Voltage source converter, Series voltage controller, Shunt controller, Combined shunt and seriescontroller.
PQ and EMC standards:Introduction to standardization, IEC electromagnetic compatibility standards, European voltagecharacteristics standards, PQ surveys.

TEXT BOOKS:

1. Math H J Bollen, "Understanding Power Quality Problems" Wiley Publications, Volume 5, 2000.
2. C. Sankaran,"Power Quality", CRC Presss,First Edition, 2002.
3. Alexander Kusko, Marc Thompson, "Power Quality in Electrical Systems", Tata McGraw Hill Publishing Co. Ltd., New Delhi, First Edition, 2007.
4. SurajitChattopadhyay, MadhuchhandaMitra, SamarjitSengupta, "Electric Power Quality", Springer, First Edition, 2007.

REFERENCE BOOKS:

1. R. SastryVedamMulukutlaS.Sarma, "Power Quality VAR Compensation in Power Systems", CRC Press, First Edition, 2008.
2. Roger C. Dugan , Mark F. McGranaghan, SuryaSantoso, H. Wayne Beaty, "Electrical Power Systems Quality", Tata McGraw Hill Education Private Ltd, New Delhi, Second Edition, 2003.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

M.Tech. EPS	**L T**	**P**	**C**
I Year -II Semester	**30**	**0**	**3**

PROGRAM ELECTIVE – 3: HVDC TRANSMISSION

Prerequisite: Power Transmission Systems

Course Objectives:

1. Evaluation of technical and economical aspects of HVDC transmission.
2. Development of HVDC converter analysis.
3. Know about VSC HVDC control.
4. Impact of AC system performance on DC system.
5. Analysis of harmonics and their rectification.

Course Outcomes:

Upon the completion of the subject, the student will be able to

6. Compare the differences between HVDC and HVAC transmission.
7. Analyze the rectifier and inverter commutating circuits.
8. Identification of valve firing control schemes.
9. Estimate the requirement of HVDC filters.
10. Address the role of AC system faults on HVDC system.
11. Know about VSC transmission advantages.

UNIT-I: Introduction:General consideration, Power handling capabilities of HVDC Lines,

Basic Conversion principles,Static converter configuration.

UNIT-II: Static power converters:3-pulse, 6-pulse, and 12-pulse converters, Converter station and Terminal equipment,Commutation process, Rectifier and inverter operation,
Equivalent circuit for converter – Specialfeatures of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC andDC filters.

UNIT-III: Control of HVDC converters and Systems:Constant current, Constant extinction angle and constant ignition angle control, Individual phasecontrol and equi-distant firing angle control DC power flow control.
Interaction between HV AC andDC systems – Voltage interaction, Harmonic instability problems and DC power modulation.

UNIT-IV: MTDC systems& over voltages: Series parallel and series parallel systems their operation and control.Over voltages due to disturbances on DC side,
Over voltages due to DC and AC side line faults.

UNIT-V: Converter faults & protection:Converter faults, Over current protection –
Valve group, and DC line protection over voltage protection of converters, Surge arresters.

TEXT BOOKS:

1. E.W. Kimbark, “Direct Current Transmission”, Wiley Inter Science, New York, Volume 1, 1971.

2. KR Padiyar,“High Voltage Direct current Transmission”,New Age International Publishers, First Edition Reprint, 1992.

REFERENCE BOOKS:

1. J. Arillaga,“HVDC Transmission”, Institution of Electrical Engineers, Second Edition, 1998..
2. E. Uhlman, “Power Transmission by Direct Current”, Springer Verlag, Berlin Helberg, First Edition, 1985.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 4:VOLTAGE STABILITY

Prerequisite: Computers Methods in Power Systems

Course Objectives:

1. To expose to theoretical background of voltage stability.
2. To illustrate voltage stability analysis using P-V and Q-V curves.
3. To be familiar with the analytical methods of voltage stability analysis.
4. To understand the basic concept and types of reactive power compensation.
5. To infer the computation of voltage stability margin and methods of voltage stability improvement.

Course Outcomes:

After the completion of the subject, the student will be able to:

1. Summarize theoretical background of voltage stability.
2. Illustrate voltage stability analysis using P-V and Q-V curves.
3. Apply analytical methods for voltage stability analysis.
4. Understand the basic concept and types of reactive power compensation.
5. Compute voltage stability margin for voltage stability improvement.

UNIT–I: Introduction to voltage stability:Definitions: Voltage stability, Voltage collapse, Voltage security; Physical relation indicatingdependency of voltage on reactive power flow;
Factors affecting voltage collapse and instability;Previous cases of voltage collapse incidences.

UNIT–II: Graphical analysis of voltage stability:Comparison of voltage and angular stability of the system; Graphical methods describing voltagecollapse phenomenon:
P-V and Q-V curves; detailed description of voltage collapse phenomenonwith the help of Q-V curves.

UNIT–III: Analysis of voltage stability:Analysis of voltage stability on SMLB system: Analytical treatment and analysis.Voltage stability indices:Voltage collapse proximity indicator;
Determinant of Jacobin as proximity indicators; Voltagestability margin.

UNIT–IV: Power system loads:Loads that influences voltage stability: Discharge lights, Induction Motor, Air-conditioning, heatpumps, electronic power supplies, OH lines and cables.
Reactive power compensation: Generation and Absorption of reactive power; Series and Shunt compensation; Synchronous condensers, SVCs; OLTCs; Booster Transformers.

UNIT–V: Voltage stability margin:Stability Margin: Compensated and un-compensated systems.Voltage Security: Definition; Voltage security;
Methods to improve voltage stability and its practical aspects.

TEXT BOOKS:

1. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwerpublishers,1998.
2. P. Kundur, "Power System Stability and Control", Tata McGraw-Hill PublishingCompany Ltd., New Delhi, 1993.
3. Carson W. Taylor, "Power System Voltage Stability", McGraw-Hill Ryerson, Limited, 1994.

REFERENCE BOOKS:

1. R. Ramnujam, "Power System Dynamics Analysis and Simulation", PHI LearningPrivate Limited, New Delhi, 2009
2. Mir Sayed Shah Danish, "Voltage Stability in Electric Power System: A Practical Introduction", Logos Verlag Berlin Gmbh, 2015.
3. Carson W. Taylor, "Reactive Power Compensation and Voltage Stability: Removing Transmission Limitations", Carson Taylor Seminars, 1989.

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UGC AUTONOMOUS

	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 4: AI TECHNIQUES IN ELECTRICAL ENGINEERING

Course Objectives

4. The concepts of learning methods.
5. Knowledge on the artificial neural networks and their architecture.
6. Applications of artificial neural networks.
7. The concepts of the fuzzy logic control and their real time applications.
8. Design concepts of associative memories.

Course Outcomes

Upon the completion of the subject, the student will be able to

9. Define the advances in neural networks.
10. Evaluate the design and control of fuzzy systems.
11. Evaluate the design of various models in neural networks.
12. Analyze the techniques of various types of neural networks.
13. Design fuzzy logic system.

UNIT – I: Artificial neural networks:Introduction-Models of neural network - Architectures – Knowledge representation – Artificialintelligence and neural networks–Learning process –

Error correction learning – Hebbian learning –Competitive learning –Boltzman learning – Supervised learning – Unsupervised learning– Reinforcement learning.

UNIT- II: ANN Paradigms:Multi – layer perceptron using Back propagation algorithm, Self – organizing Map –
Radial basisfunction network – Functional link, network – Hopfield network.

UNIT – III: Fuzzy logic:Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic fuzzy setoperations – Properties of fuzzy sets –
Fuzzy cartesionproduct –Operations on fuzzy relations– Fuzzy logic – Fuzzy quantifiers-Fuzzy inference-Fuzzy rule based system- Defuzzificationmethods.

UNIT – IV: Genetic Algorithms:Introduction-Encoding –Fitness function-Reproduction operators-Genetic modeling –Geneticoperators – Crossover- Single – Site crossover-Two point crossover – Multi point crossover-Uniformcrossover –
Matrix crossover-Crossover rate-Inversion &deletion – Mutation operator –Mutation–Mutation rate-Bit-wise operators-Generational cycle-convergence of genetic algorithm.

UNIT–V: Applications of AI techniques:Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Singlearea system and two area system –
Small signal stability (Dynamic stability), Reactive powercontrol – Speed control of DC and AC Motors.

TEXT BOOKS:

1. S.Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms”- PHI, New Delhi, 2003.

REFERENCE BOOKS:

1. P.D.Wasserman, Van Nostrand Reinhold, “Neural Computing Theory & Practice”- New York,1989.
2. Bart Kosko, “Neural Network & Fuzzy System”. Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger, “Fuzzy Sets,Uncertainty and Information”-PHI, Pvt.Ltd,1994.
4. D.E.Goldberg,” Genetic Algorithms”, Addison Wesley, 1999.

J.B.INSTITUTE OF ENGINEERING & TECHNOLOGY
UGC AUTONOMOUS

M.Tech. EPS	**L**	**T**	**P**	**C**
I Year -II Semester	**30**		**0**	**3**

PROGRAM ELECTIVE – 4: REACTIVE POWER COMPENSATION AND MANAGEMENT

Prerequisite: Reactive Power Compensation and Management

Course Objectives:

1. A deep insight in load compensation with respect to their characteristics.
2. Analysis of steady state and transient state reactive power compensation in transmission system.
3. Knowledge on reactive power coordination.
4. Knowledge on demand side and distribution side reactive power management.
5. Information on typical layout of traction systems.

Course Outcomes:

Upon the completion of the lab, the student will be able to

6. Evaluate the design and control of different types of compensation.
7. Articulate User side reactive power management.
8. Articulate steady state and transient state reactive power compensation.
9. Techniques for analyzing of reactive power management.
10. Evaluate reactive power control requirements

UNIT-I: Load Compensation:Objectives and specifications – Reactive power characteristics – Inductive and capacitiveapproximate biasing –

Load compensator as a voltage regulator – Phase balancing and powerfactor correction of unsymmetrical loads- examples.

UNIT-II: Steady **s**tate reactive power compensation in transmission system: Uncompensated line – Types of compensation – Passive shunt and series and dynamic shuntcompensation –Examples.

Transient state reactive power compensation in transmission systems: Characteristic time periods – Passive shunt compensation – Static compensations- Series capacitor compensation –Compensation using synchronous condensers – Examples

UNIT-III: Reactive Power Coordination**:** Objective – Mathematical modeling – Operation planning – Transmission benefits – Basicconcepts of quality of power supply –
Disturbances- steady –State Variations – Effects of undervoltages – Frequency –Harmonics, RF and electromagnetic interferences.

UNIT-IV: Demand side management: load patterns – Basic methods load shaping – Power tariffs-KVAR based tariffs penalties for voltage flickers and harmonic voltage levels.
Distribution side reactive power management:System losses –Loss reduction methods – Examples – Reactive power planning – Objectives –Economics Planning capacitor placement – Retrofitting of

capacitor banks.

UNIT-V: User side reactive power management: KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of available capacitor, characteristics and Limitations.
Reactive power management in electric traction systems and are furnaces: Typical layout of traction systems – Reactive power control requirements – Distribution transformers- Electric arc furnaces – Basic operations- Furnaces transformer –Filter requirements – Remedial measures –Power factor of an arc furnace.

TEXT BOOKS:

1. T.J.E.Miller, "Reactive Power Control in Electric Power Systems", John Wiley and Sons, 1982.
2. D.M.Tagare, "Reactive Power Management", Tata McGraw Hill,F8irst Reprint, 2007.

REFERENCE BOOKS:

1. Wolf Gang Hofman, "Reactive Power Compensation: A Practical Guide", John Wiley and Sons—1st Edition, 2012.
2. AbhijitChakrabarthi,"Introduction to Reactive Power Control and Voltage Stability in Power Transmission Scheme" PHI, Eastern Economy,1st Edition, 2010.

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	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**0**	**0**	**4**	**2**

LABORATORY – 3: POWER SYSTEMS LAB – II

Prerequisites: Power System Analysis, Power System Protection

Course Objectives:

3. To understand the Performance of Transformers and Synchronous Machines.
4. To select the Transmission Lines, UG Cables, String Insulators, CTs and PTs.
5. To analyze the characteristics of OC, UV/OV, negative sequence relays.

Course Outcomes:

Upon the completion of the lab, the student will be able to

1. Test and evaluate the performance of Power Transformers and Synchronous Machines.
2. Test and evaluate the performance of Transmission lines, UG Cables, Insulators and other Auxiliary Power Systems Equipment Test.
3. Evaluate/Choose the various types of Relays (Electromagnetic, Static andMicroprocessor based relays).

List of Experiments:

1. Determination of Equivalent circuit of a 3-Winding Transformer.
2. Determination of Sequence Impedances of Three Phase Transformer.
3. Characteristics of Over Current Relays i. IDMT Electromagnetic Relay (7051 A). ii. Microprocessor based Relay (7051 B).
4. Characteristics of Percentage biased Differential Relay(Electromagnetic Relay (7054 A).
5. Characteristics of Over Voltage Relay. I. Electromagnetic Relay (7053 A). II. Microprocessor based Relay (7053 B).
6. Characteristics of Under Voltage (UV) and Negative sequence Relays i. UV Electromagnetic Relay (7052 A). ii. UV Microprocessor Based Relay (7052 B). iii. Static Negative Sequence Relay (7055 B).
7. Performance and Testing of Transformer Protection System.
8. Performance and Testing of Feeder Protection System.
9. Performance and Testing of Transmission Line Model.
10. Differential protection on Single Phase Transformer.

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	L	T	P	C
M.Tech. EPS				
I Year -II Semester	**0**	**0**	**4**	**2**

LABORATORY – 4: ELECTRICAL SIMULATION LAB-2

Course Objectives:

1. To have the knowledge of optimization techniques used in the power system and Load Frequency Control (LFC).
2. To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in Turbine models.
3. To analyze the effects of faults on single machine system connected to infinite bus.
4. To simulate the single and three phase converters with RLE loads.

Course Outcomes:

1. Express economic operation of power system and importance of LFC control.
2. To improve student's ability in solving problems related to Economic Load Dispatch, Load Frequency Control and reactive power control.
3. Ability to discuss single area load frequency control and two area load frequency control.
4. Ability to model and design turbine and automatic controller.

List of Experiments:

1. Modeling of single area and multi line Load frequency control in MATLAB SIMULINK.
2. Modeling AVR in MATLAB SIMULINK .
3. Modeling IEEE excitation systems in MATLAB SIMULINK.
4. Study of effect of Faults (LG, LL, LLG, 3 phase) on a single machine connected to infinite Bus.
5. Representation of Sequence Networks.
6. Modeling of Turbine and Governor System
7. Solution of Swing Equation by any one method.
8. Simulation of Single phase full converter using RL and E loads.
9. Simulation of Three phase full converter using RL and E loads.
10. Simulation of Single phase AC Voltage controller using RL load.
11. Simulation of Three phase inverter with PWM controller.

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M.Tech. EPS **L T P C**
I Year -II Semester **2 0 0 0**

AUDIT - II: VALUE EDUCATION

Course Objectives:

12. Understand value of education and self- development.
13. Imbibe good values in students.
14. Let students know about the importance of character.

Course Outcomes:

After completing this session, student will be able to

15. Knowledge of self-development.
16. Learn the importance of Human values.
17. Developing the overall personality.

UNIT I: Values and self-development –Social values and individual attitudes,

Work ethics, Indian vision of humanism,Moral and non- moral valuation, Standards and principles, Value judgements.

UNIT II: Importance of cultivation of values, Sense of duty, Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness,
Honesty, Humanity, Power of faith, National unity. Patriotism, Love for nature, Discipline.

UNIT III: Personality and behaviour development - Soul and scientific attitude. Positive thinking. Integrity and discipline, Punctuality, Love and kindness, Avoid fault thinking. Free from anger, Dignity of labour.

UNIT IV: Universal brotherhood and religious tolerance. True friendship,
Happiness Vs suffering, love for truth. Aware of self-destructive habits,Association and cooperation,Doing best for saving nature.

UNIT V: Character and Competence - Holy books vs Blind faith, Self-management and Good health. Science of reincarnation, Equality, Non violence ,Humility,
Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively.

TEXT BOOKS:

1. Chakroborty , S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press,New Delhi

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M.Tech. EPS				
II Year -I Semester	**3**	**0**	**0**	**3**

PROGRAM ELECTIVE - 5: RELIABILITY ENGINEERING

Prerequisite: Probability and Distribution

Course Objectives

2. To comprehend the concept of reliability and unreliability
3. Derive the expressions for probability of failure, Expected value and standard deviation of Binominal distribution, poisson distribution, normal distribution and weibull distributions.
4. Formulating expressions for reliability analysis of series-parallel and non-series parallel systems
5. Derive expressions for time dependent and limiting state probabilities using markov models.

Course Outcomes

Upon the completion of the subject, the student will be able to

1. Apply fundamental knowledge of reliability to model and analyze series parallel and non-series parallel systems.
2. Solve some practical problems related with generation, transmission and utilization of electrical energy.
3. Understand or become aware of various failures, causes of failures and remedies for failures in practical systems.

UNIT I: Rules for combining probabilities of events, Definition of reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables,

Probability density and distribution functions. Mathematical expectation, Binominal distribution, Poisson distribution, Normal distribution, Weibull distribution.

UNIT II: Hazard rate, Derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, Types of failures (early failures, chance failures and wear-out failures).
Bath tub curve. Preventive and corrective maintenance. Modes of failure. Measures of reliability: Mean time to failure and mean time between failures.

UNIT III: Classification of engineering systems: series, Parallel and series-parallel systems-Expressions for the reliability of the basic configurations.
Reliability evaluation of non-series- parallel configurations: Decomposition, Path based and cutest based methods, Deduction of the paths and cutsets from Event tree.

UNIT IV: Discrete markov chains: General modelling concepts, Stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation of one component repairable model. Absorbing states. Continuous markov processes:
Modelling concepts, State space diagrams, Stochastic transitional probability matrix, Evaluating time dependent and limiting state probabilities of one component repairable model. Evaluation of limiting state probabilities of two component repairable model.

UNIT-V: Approximate system reliability analysis of series systems, Parallel systems with two and more than two components, Network reduction techniques.

Minimal cutest/failure mode approach. **TEXT BOOKS:**

1. Roy Billinton and Ronald N Allan, "Reliability evaluation of Engineering systems", Springer Publications, Second Edition, 1992.
2. Elsayed A. Elsayed, "Reliability Engineering", Wiley Publications, Second Edition, 2012.

REFERENCE BOOKS:

1. Alessandro Birolini, "Reliability Engineering: Theory and Practice", Springer Publications. Eighth Edition, 2017.
2. Charles Ebeling, "An Introduction to Reliability and Maintainability Engineering", Tata Mc Graw Hill Publications, New Delhi, Eighth Reprint, 2007.
3. E. Balaguruswamy, "Reliability Engineering", Tata Mc Graw Hill Publications, New Delhi, Tenth Reprint, 2010.

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M.Tech. EPS				
II Year -I Semester	**3**	**0**	**0**	**3**

PROGRAM ELECTIVE - 5:MODERN CONTROL THEORY

Prerequisite: Control Systems

Course Objectives:

1. To explain the concepts of basic and modern control system for the real time analysis and design of control systems.
2. To apply concepts of state variables analysis.
3. To study and analyze non-linear systems.
4. To gain the knowledge of phase plane methods.
5. To analyze the concept of stability of nonlinear systems and categorization.

Course Outcomes:

Upon completion of this course, students should be able to:

1. Apply the knowledge of basic and modern control system for the real time analysis.
2. Design the real time control systems.
3. Understand the concepts of state variables analysis.
4. Analyze the concept of stability of nonlinear systems.
5. Get the knowledge on phase plane methods.

UNIT–I: State variable analysis: The concept of state – State equations for dynamic systems– Time invariance and linearity – Non-uniqueness of state model – State diagrams for continuous - Time state models. Linear continuous time models for physical systems –
Existence and uniqueness of solutions to continuous-Time state equations – Solutions of linear time invariant continuous - Time state equations – State transition matrix and its properties.

UNIT-II: State variable analysis &design: General concept of controllability – General concept of observability – Controllability tests for continuous-Time invariant systems –
Observability tests for continuous-Time invariant systems – Controllability and observability of state model in Jordan Canonical form – Controllability and observability canonical forms of state model.

UNIT-III: Non - linear systems: Introduction – Non-linear systems - Types of non linearities – Saturation – Dead-Zone - Backlash – Jump phenomenon etc;– Singular points – Introduction to linearization of non-linear systems, Properties of non-linear systems –
Describing function– Describing function analysis of non-linear systems – Stability analysis of non-linear systems through describing functions.

UNIT-IV: Phase plane methods:Introduction to phase-plane analysis,
Method of isoclines for constructing trajectories, Singular points, Phase-plane analysis of non-linear control systems.

UNIT-V: Stability analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems –

Stability analysis of the linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's

method. State feedback controller design through pole assignment – State observers: Full order and reduced order.

TEXT BOOKS:

1. M.Gopal, "Modern Control System Theory", New Age International, Revised Second Edition, 1993.
2. OgataKatsuhiko, "Modern Control Engineering", Pearson Education Publication, Fifth Edition,2010.

REFERENCE BOOKS:

1. Richard C. Dorf, Robert H. Bishop "Modern Control Systems", Prentice Hall Publications, Second Edition, 2001.
2. A. Nagoorkani,"Advanced Control Theory" RBA Publications,Second Edition, 1999.

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M.Tech. EPS				
II Year -I Semester	**3**	**0**	**0**	**3**

PROGRAM ELECTIVE - 5:ADVANCED DIGITAL SIGNAL PROCESSING

Prerequisite: Digital Signal Processing

Course Objectives:

1. To Comprehend characteristics of discrete time signals and systems
2. To analyze and process signals using various transform techniques.
3. To identify various factors involved in design of digital filters.
4. To illustrate the effects of finite word length implementation

Course Outcomes:

Upon the completion of the subject, the student will be able to

5. Analyze and process signals in the discrete domain.
6. Design filters to suit specific requirements for specific applications.
7. Perform statistical analysis and inferences on various types of signals.
8. Design multi rate signal processing of signals through systems.
9. Analyze binary fixed point and floating-point representation of numbers and arithmetic operations.

UNIT–I: Digital filter structures: Block diagram representation – Equivalent structures – FIR and IIR digital filter structures All pass Filters-tenable IIR Digital sine-cosine generator- Computational complexity of digital filter structures.

UNIT–II: Digital filter design: Preliminary considerations- Bilinear transformation method of IIR filter design – Design of Low pass high-pass – Band-pass, and Band stop- IIR digital filters – Spectral transformations of IIR filters – FIR filter design – Based on windowed Fourier series – Design of FIR digital filters with least mean square-error – Constrained least square design of FIR digital filters.

UNIT-III: DSP algorithm implementation: Computation of the discrete Fourier transform- Number representation – Arithmetic operations – Handling of overflow – Tenable digital filters – Function approximation.

UNIT-IV: Analysis of finite word length effects: The Quantization process and errors-Quantization of fixed –Point and floating –Point Numbers – Analysis of coefficient- Quantization effects – Analysis of arithmetic round-off errors- Dynamic range scaling – Signal –to- noise in Low –Order IIR filters- Low – Sensitivity Digital filter – Reduction of product round-off errors feedback – Limit cycles in IIR digital filter – Round-off errors in FFT Algorithms.

UNIT-V: Power spectrum estimation: Estimation of spectra from finite duration observations signals- Nonparametric methods for power spectrum estimation- parametric method for power spectrum estimation - Estimation of spectral form-Finite duration observation of signals- Non-

parametric methods for power spectrum estimation – Walsh methods – Blackman and torchy method

TEXT BOOKS:

1. John G. Proakis,"Digital Signal Processing Principles –Algorithms and Applications", PHI Publications,Third Edition, 2002.
2. Alan V. Oppenheim, Ronald W,Shafer,"Digital Time Signal Processing", PHI Publications,st Edition reprint,1996.
3. Glenn Zelniker, Fred J. Taylor, "Advanced Digital Signal Processing – Theory and Applications" First Edition, 1994.

REFERENCE BOOKS

1. S Salivahanan. A Vallavaraj C. Gnanapriya, "Digital Signal Processing", Tata Mc Graw HillSecond Edition Reprint, 2001.
2. Sanjit K. Mitra,"Digital Signal Processing", Tata Mc Graw Hill,Fourth Edition, 2010.
3. J.S. Chitode, "Digital Signal Processing", Technical Publications, First Edition, 2008.

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II Year -I Semester	**3**	**0**	**0**	**3**

OPEN ELECTIVE - RENEWABLE ENERGY SYSTEMS

Objectives:

1. To provide the knowledge on principles of solar radiation & solar energy collection & storage and applications.
2. To prepare graduates to express the Knowledge on wind energy, geo-thermal energy, ocean energy plants.

Outcomes:

3. Graduate will able to gather the solve the problem facing the world like power generation, energy conservations like bio-mass, tidal & wave energies

UNIT-I: Photo voltaic power generation, Spectral distribution of energy in solar radiation, Solar cellconfigurations, Voltage developed by solar cell, Photo current and load current, Practical solar cellperformance, Commercial photo voltaic systems, Test specifications for PV systems, Applicationsof super conducting materials in electrical equipment systems.

UNIT-II: Principles of MHD power generation, ideal MHD generator performance, Practical MHDgenerator, MHD technology.
Wind energy conversion:Power from wind, Properties of air and wind, Types of wind turbines, Operating characteristics.

UNIT-III: Tides and tidal power stations, Modes of operation, Tidal project examples, Turbines andgenerators for tidal power generation.
Wave energy conversion:Properties of waves and power content, vertex motion of Waves, Device applications. Types of ocean thermal energy conversion systems, Application of OTECsystems examples.

UNIT-IV: Miscellaneous energy conversion systems:Coal gasification and liquefaction, Biomassconversion, Geothermal energy, Thermo electric energy conversion, Principles of EMF generation, Description of fuel cells, Co-generation and energy storage, Combined cycle co-generation, Energy storage.
Global energy position and environmental effects: Energy units, Global energy position.

UNIT-V: Types of fuel cells, H_2-O_2 Fuel cells, Application of fuel cells – batteries, Description of batteries,Battery application for large power. Environmental effects of energy conversion systems, Pollutionfrom coal and preventive measures, Steam stations and pollution, Pollution free energy systems.

TEXT BOOKS:

1. Rakosh das Begamudre,"Energy Conversion Systems", New age International publishers, 1st Edition, New Delhi - 2000.
2. John Twidell and Tony Weir,"Renewable Energy Resources", Fspon& Co. Routledge Publishers, 3rd Edition, 2015.
3. David M. Buchla, Thomas E. Kissel, Thomas L. Floyd, "Renewable Energy Systems", Pearson Publications, 1st Edition 2015.

REFERENCE BOOKS:

1. G. D. Rai, "Non-Conventional Energy Sources", Khanna Publishing House, 5th Edition, 2010.
2. Henrik Lund, "Renewable Energy Systems" -Academic Press, 1st Edition 2009.

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M.Tech. EPS				
II Year -I Semester	**3**	**0**	**0**	**3**

OPEN ELECTIVE – POWER PLANT ENGINEERING

Objectives:

3. To provide the knowledge on principles of solar radiation & solar energy collection & storage and applications.
4. To prepare graduates to express the Knowledge on wind energy, geo-thermal energy, and ocean energy plants.
5. To understand the behaviour of different power plants.

Outcomes:

6. Graduate will able to gather the solve the problem facing the world like power generation, energy conservations like bio-mass, tidal & wave energies.

UNIT I: Thermal power plants: Basic thermodynamic cycles, Various components of steam power plant-Layout-Pulverized coal burners- Fluidized bed combustion-Coal Handling systems- Ash handling systems- Forced draft and induced draft fans- Boilers- Feed pumps- Super heater-Regenerator-Condenser- Dearearators- Cooling tower.

UNIT II: Hydro electric power plants: Layout-Dams-Selection of water turbines – types-Pumped storage hydel plants

UNIT III: Nuclear power plants: Principles of nuclear energy- Fission reactions-Nuclear reactor-Nuclear power plants

UNIT IV: Gas and diesel power plants: Types, Open and closed cycle gas turbine, Work output & thermal efficiency, Methods to improve performance-reheating, Inter-coolings, Regeneration-Advantage and disadvantages- Diesel engine power plant, Component and layout.

UNIT V: Non-conventional power generation: Solar energy collectors, OTEC, Wind power plants, Tidal power plants and geothermal resources, Fuel cell, MHD power generation- Principle, Thermoelectric power generation, Thermionic power generation.

TEXT BOOKS

1. Arora and Domkundwar, “A Course in Power Plant Engineering” DhanpatRai and Co.Pvt.Ltd., New Delhi.
2. P.K. Nag, “Power Plant Engineering”, Tata McGraw Hill, Second Edition, Fourth reprint 2003.

REFERENCE BOOKS:

1. Bernhardt G.A.Skrotzki and William A. Vopat, "Power Station Engineering and Economy", Tata McGraw Hill Publishing Company Ltd., New Delhi, 20th reprint 2002.
2. G.D. Rai, "An Introduction to Power Plant Technology",Khanna Publishers, Delhi- 110 005.
3. M.M. El-Wakil, "Power Plant Technology", TataMcGraw Hill, New Delhi, 1984.