CURRICULUM & SYLLABI
2024-2025

M.TECH.
IN
ELECTRICAL POWER SYSTEM MANAGEMENT

DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF ENGINEERING AND TECHNOLOGY
JAMIA MILLIA ISLAMIA
NEW DELHI-110025

M. TECH. IN ELECTRICAL POWER SYSTEM MANAGEMENT
UNDER NEP 2020

M.Tech. Electrical Power System Management
Effective from 2024-25

Category of Courses

DC: Departmental core
CBCS: Choice Based Credit System
SEC: Skill Enhancement Courses
AECC: Ability Enhancement Compulsory Course
DE: Departmental electives

Abbreviation

L Lecture
T Tutorial
P Practical
CCA Continuous Class Assessment
MSE Mid Semester Evaluation

I Year

First Semester												
S. No	Course No.	Course Name	Type of Course	CREDIT	Periods Per week			Examination Scheme (Distribution of Marks)				
								Mid Semester Evaluation			End Semester Evaluation	Total Marks
					L	T	P	CCA	MSE-1	MSE-2		
01	EEM-101	Intelligent Techniques	**CBCS**	4	3	1	-	10	15	15	60	100
02	EEM-107	Automation Systems	**DC**	4	3	1	-	10	15	15	60	100
03	EEM-109	Power System Modeling	**DC**	4	3	1	-	10	15	15	60	100
04	EEM-111	Renewable and Sustainable Energy Systems	**DC**	4	3	1	-	10	15	15	60	100
05	-	Elective-1	**DE**	4	3	1	-	10	15	15	60	100
PRACTICAL (LAB.)												
06	EEM-134	SCADA Lab	**SEC**	2	-	-	4	30	-	-	20	50
			Total	**22**								**550**
Elective –I: EEM-114 Communication Protocol /EEM-106 Applied Mathematics for Engineers/EEM-113 Power Quality and FACTS												
Second Semester												
01	EEM-201	Optimization Techniques	**CBCS**	4	3	1	-	10	15	15	60	100
02	EEM-209	Power System Dynamics and Stability	**DC**	4	3	1	-	10	15	15	60	100
03	EEM-211	Smart Grid Technologies	**AECC**	4	3	1	-	10	15	15	60	100
04	-	Elective-II	**DE**	4	3	1	-	10	15	15	60	100
05	-	Elective-III	**DE**	4	3	1	-	10	15	15	60	100
PRACTICAL (LAB.)												
06	EEM-239	Power System Automation Laboratory	**SEC**	2	-	-	4	30	-	-	20	50
	EEM-240	Seminar	**SEC**	2	-	-	4	30	-	-	20	50
			Total	**24**							**Total**	**600**
Elective –II: EEM-213 Digital Power System Protection/EEM- 214 Power System Planning and Reliability **Elective-III**: EEM-204 Modelling and Simulation /EEM-215 Power System Analysis/EEM-216 Digital Communication												

II Year

Third Semester												
S. No.	Course No.	Course Name	Type of Course	CREDIT	Periods Per week			Examination Scheme (Distribution of Marks)				
								Mid Semester Evaluation			End Semester Evaluation	Total Marks
					L	T	P	CCA	MSE-1	MSE-2		
01	-	Elective –IV	**SEC**	4	3	1	-	10	15	15	60	100
02	-	Elective –V	**CBCS**	4	3	1	-	10	15	15	60	100
PRACTICAL (LAB.)												
06	EEM-350	Minor Project	**DC**	8	-	-	16	120	-	-	80	200
			Total	**16**								**400**
Elective –IV: EEM-307 Restructuring and Deregulation of Power System/EEM -306 Advanced Power Electronics **Elective –V:** EEM-308 Transmission and Distribution Automation /EEM-309 EHVAC and DC Transmission												
Fourth Semester												
01	EEM-450	Dissertation	**DC**	12	-	-	24	180	-	-	120	300
			Total	**12**							**Total**	**300**

Total Credits (22+24+16+12) =**74**

EEM-101: INTELLIGENT TECHNIQUES

Credit	L	T	P
4	**3**	**1**	**-**

UNIT I:
Concepts of Natural and Artificial Intelligence (AI); Definitions, Turing Test, Achievements of AI, Limitations of AI, Soft Computing; Definition, Fundamental principles, Real world examples, Premesis and Guiding principles of Soft Computing, Difference between conventional computing and soft computing, Constituents of soft computing such as Fuzzy Logic, Neural Networks. Scope and limitations of Fuzzy Logic and Neural Networks.

UNIT II:
Linguisticvariablesand membership functions, fuzzy set theory, classical sets and fuzzy sets, fuzzy set operations, fuzzy Cartesian product, fuzzy relation, fuzzy rules.

UNIT III:
Generalized Modus Ponens and Modus Tollens rules, structure of fuzzy inference system, defuzzification methods, Mamdani model, TSK model, Case Studies.

UNIT IV:
Introduction to biological and artificial neural neuron, classification of artificial neural network; architecture, learning, activation functions, perceptron models, backpropagation networks, kohonen network, Hopfield network.

UNIT V:
Architectures of hybrid neuro-fuzzy systems, Five-layer neuro-fuzzy system, four-layer neuro-fuzzy system (ANFIS), three-layer neuro fuzzy approximator, case studies.

TEXT/REFFERENCE BOOKS

1. Fakhreddine O. Karray and Clarence W De Silva, “Soft Computing and Intelligent Systems Design: Theory, Tools and Applications” Pearson Education, 2011.
2. S. Rajasekaran and G. A. VijayalakshmiPai, “Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications”, Prentice Hall of India, New Delhi, 2011.
3. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and applications, Prentice Hall of India, New Delhi, 1997.
4. Jyh-Shing Roger, Chuen-Tsai Sun, EuiMizutani, Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall of India, New Delhi, 2005. (5) Simon S Haykin, “Neural networks and learning machines”, Prentice Hall of India, New Delhi, 2009.

EEM-107: AUTOMATION SYSTEMS

Credit	L	T	P
4	**3**	**1**	**-**

UNIT I:

Automation systems, Advantages of automation, Components of process control systems,Evolution of Control systems. Single loop control, Centralized control, Distributed controlsystems, Open systems, SCADA systems. Types of data available, Analog, Digital, Pulse data, Redundancy.Data communication components and protocols.

UNIT II:

Programmable Logic Controllers (PLC) Functional description, input/output systems, CPU,memory Unit, Programmer Units, Peripheral devices, PLC Vs Computers, Advantages of PLCs, controller programming tools, Ladder Diagram programming. phase locked loop, Interposing relays, type and structure of relays.

UNIT III:

Distributed Control Systems (DCS) PLC Vs DCS systems, DCS architecture, Local controlunits, dedicated card controllers, Unit Operations controllers, DCS multiplexers, DCS system, Integration, Automation Standards, salient features.

UNIT IV:

Supervisory Control and Data acquisition (SCADA) Systems, Types of supervisory systems, Components of SCADA Systems. Remote terminal unit (RTU), Communication subsystem, Protocols, Logic subsystem, termination subsystem, test and power supply subsystem, Phasor
measurement Units, Phasor Data concentrator and communication, Intelligent Electronic Devices.

UNIT V:

SCADA master station configurations, hardware and software components, Communication Systems, Human Machine interface. SCADA application functions, Intelligent Electronicdevices. Practical PLC, DCS, PMU and SCADA applications and implementations

TEXT/REFFERENCE BOOKS

1. Automation Handbook Vol I Bela G. Liptac, CRC Press.
2. Fundamentals of Supervisory systems, IEEE tutorial.
3. John W Webb & Ronald A Reiss, Programmable Logic Controllers, principles andapplications, Prentice Hall of India.
4. Related Research papers

Websites

- www.powermin.gov.in
- www.mnre.gov.in

EEM-109: POWER SYSTEM MODELLING

Credit	L	T	P
4	**3**	**1**	**-**

UNIT I:

Review of network matrices; introduction to graph theory, basic loops, basic cut-sets, incidence matrices, augmented cut-set and loop incidence matrices, primitive network, network performance equations, bus admittance matrix, direct inspection method, step by step procedure, singular transformation and non singular transformation.

UNIT II:

Bus impedance matrix, partial network, procedure for finding elements of Z- bus, algorithm for formulation of Z-bus with and without coupled elements, addition of branch, addition of link, modification of Z- bus for changes in network.

UNIT III:

Introduction to load flow analysis, development of load flow equations, iterative methods, Techniques used in N-R method, sparse matrix, triangular factorization, fast decoupled load flow.

UNIT IV:

Modeling of Single Machine infinite bus system, Mathematical modeling of multi machine system, Dynamics and transient stability analysis of single machine system and multi machine system.

UNIT V:

Short circuit studies of large power system networks, algorithm for calculating system condition after the occurrence of faults, comparison between symmetrical components and phase coordinated method of short circuit studies.

TEXT/REFFERENCE BOOKS

1. Modern Power system Analysis, I.J. Nagrath and D. P. Kothari; Tata Mc Graw Hill, New Delhi.
2. Electrical Power System; New Age International Publishers.
3. Power System Analysis, B. Subramanyam, B. VenkataPrasantha, I. K. International Publishing House, New Delhi.
4. Power Generation, Operation and Control, Wood and Woollenberg, John Wiley and Sons.
5. Computer Method in Power Systems, Stas El Abiad.
6. Advanced Power System Analysis and Dynamics, L.P. Singh, Wiley Eastern Limited, New Delhi.

EEM-111: RENEWABLE AND SUSTAINABLE ENERGY SYSTEM

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:

Overview of conventional and renewable energy technologies, world and India's energy scenario & Energy Security, Energy growth patterns, projection of energy demands.

UNIT-II:

Solar radiation, availability, measurements, estimation and modeling, solar thermal systems and concentrated solar power (CSP), application of solar thermal generation, photovoltaic system for power generation, PV arrays, panel sizing, MPPT Technique, stand alone PV systems, Grid connected PV systems, PV performance, Grid Integration issues, case study.

UNIT-III:

Wind resource assessments and forecasting, site assessment, power in wind, general theories of wind machines, wind energy conservation systems (WECS), and power energy-corves. Wind control and regulation mechanism, integration to the Grid.

UNIT-IV:

Potential, availability of biomass, bio conservation process, factor effecting gas generation, types of bio- gas plants, case study.

UNIT-V:

Micro grid; fuel cell, hydrogen energy, energy storage, hybrid and integrated energy systems.

Additional topics:

1. MHD generation
2. Tidal energy

TEXT/REFFERENCE BOOKS

1. B.H.Khan, Non-Conventional Energy Resources, TMH.
2. D.P.Kothari, Renewable Energy and Emerging Technologies, PHI.
3. C.S.Solanki, Solar Photovoltaic, PHI.
4. C.S.Solanki, Renewable Energy, PHI.
5. Freris L.L., Wind energy Conservation systems. PHI.
6. J.A. Duffie and W.A. Beckman, Solar Energy of thermal processes, John Wiley.
7. S.P. Sukhatme, Solar Energy-Principle of Thermal Collection and storage, THM.
8. MNRE Manual.

Websites:

1. www.nptel.ac.in
2. www.mnre.gov.in

EEM-134: SCADA LAB

Credit L T P
2 - - 4

List of Experiments

I. Observe, draw and analyze hardware architecture of the SCADA lab.

II. Plan and install the field instruments and transducers including wiring in the SCADA Laboratory.

III. Integrate the "Field model to the input/output units of the RTU through data acquisition / signal conditioning and make the detail signal flow block diagram.

IV. Set up the LAN for the SCADA Lab and test the communication between workstation and the controller.

V. Build a SCADA project on compact control builder AC800M to map the available hardware infrastructure in the SCADA Lab.

VI. Build the FBD (Functional Block Diagram) logic to find out the occurrence of "Ferranti effect".

(i) Create monitoring and display of the sending _end and receiving _end voltage and current values.
(ii) Create control for different contactors to simulate switching events.

VII. (i) Testing of the created FBD logic in off-line mode.
(iii) Deploying the SCADA project to the controller AC800M.
(iv) Testing the FBD logic in on-line mode.

VIII. Develop a GUI (Graphical User Interface)/ HMI for the system operator to monitor and control the SCADA project.

IX. Configure the SCADA project for producing trends and alarms and commission it to demonstrate the implemented function.

X. Configure the SCADA project for the control of a variable frequency drive.

EEM-114: COMMUNICATION PROTOCOLS

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-1:

Communication Basics, OSI Architecture, Network Classification, Device Networks, Control Networks, Enterprise Networks,

UNIT-2:

Introduction to Networks in process automation, Information flow requirements, Industry Networks, Network Selection

UNIT-3:

Network Architectures, Building Blocks, Industry Open Protocols: RS-232, RS-422, RS-485, Ethernet, Modbus, Profibus, Fielsbus: Trends, Hradware, Field Bus Design, Advantages and Limitations

UNIT-4:

WPAN, Wi-Fi, Bluetooth, Zigbee, Z-wave, IRIB-B

UNIT-5:

Communication Requirements for Substation Automation Systems: Data Load Analysis, Need for Interoperable communication, Overview of IEC 61850 Standard: Data Models, Communication Services, GOOSE Communication: Implementation and its Advantages.

TEXT/REFFERENCE BOOKS

1. B.G. Liptak, “Process Software and Digital Networks”, fourth Edition, Volume III, CRC Press ISA-The Instrumentation, Systems and Automation Society, 2012.
2. Deon Reynders, Steve Mackay and Edwin Wright, “Practical Industrial Data Communication- Best Practice Techniques”, Newnes, Elsevier, IDC Technologies, 2005, ISBN- 0 7506 6395 2.
3. Peterson Davie, “Computer Networks-A Systems Approach”, Maugann Kauffmann Publisher, 3rd Edition, 2003.
4. User Manuals of Foundation Field Bus, Profibus, Modbus, Ethernet, DeviceNet, ControlNet, IEC61850.

EEM-106 APPLIED MATHEMATICS FOR ENGINEERS

Credit L T P

4 3 1 0

UNIT-I Advanced Matrix Theory

Eigen-values using QR transformations – Generalized eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse – Least square approximations.

UNIT-II Linear Programming

Formulation – Graphical Solution – Simplex Method – Two Phase Method – Transportation and Assignment Problems.

UNIT-III One Dimensional Random Variables

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT-IV Queueing Models

Poisson Process – Markovian queues – Single and Multi-Server Models – Little's formula – Machine Interference Model – Steady State analysis – Self Service queue.

UNIT-V Computational Methods in Engineering

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

Text/Reference Books:

1. Bronson, R., Matrix Operation, Schaum's outline series, McGraw Hill, New York.
2. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Asia, New Delhi.
3. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers & Scientists, Asia.
4. Donald Gross and Carl M. Harris, Fundamentals of Queueing theory, John Wiley and Sons, New York.

EEM-113: POWER QUALITY AND FACTS

Programme: M. Tech. (EPSM) I Semester **Internal Assessment: 40**
End Examination: 60

Credit: 4 L T P: 3: 1: 0

EEM-113: POWER QUALITY AND FACTS

Unit - 1

Definition of Power Quality, Power Quality Issues, Power Quality Indices, Power Quality v/s Equipment Immunity, Electric Power Quality Standards, Power Frequency Disturbances, Voltage Sag, Isolation Transformers, Voltage Regulators, Uninterruptible Power Source Systems and non-linear loads.

Unit - 2

Types and causes of Transients, Definition of Harmonics, Causes of Voltage and Current Harmonics, Individual and Total Harmonic Distortion, Effect of Harmonics on Power System Devices, Guidelines for Harmonic Voltage and Current Limitation, Harmonic Mitigation.

Unit - 3

Power Quality Measurement Devices: Harmonic Analyzers, Transient – Disturbance Analyzers; Analysis: Analysis in the Periodic Steady State, Time Domain Methods, Frequency Domain Methods, Elimination/Suppression of Harmonics using Passive, Active and Hybrid Filters.

Unit - 4

FACTS Concepts and General Considerations, Converters for Static Compensation, Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM): Operation, Control and Comparison, Static Series Compensation, Static Voltage Phase Angle Regulators: TCVR & TCPAR, Unified Power Flow Controllers – Operation, Comparison with other FACTS Devices, Control of P and Q, Special Purpose FACTS Devices, Interline Power Flow Controllers: Operation and Control.

Unit - 5

Power Quality Issues related to Distribution Systems – Custom Power Devices – Distribution STATCOM – Dynamic Voltage Restorer – Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC for improving Power Quality in Distribution Systems.

Test/Reference Books:

1. Narain G. Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi- 110 006, 2011.
2. Ghosh, A. and Ledwich,G., Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers (2005).
3. V.K. Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers, 2004.

4. K. R. Padiyar, ”FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Limited, Publishers, New Delhi, 2008.
5. R. Mohan Mathur, Rajiv K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc, 2002.
6. Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, “Flexible AC Transmission System: Modelling and Control” Springer, 2012.
7. Sang, Y.H. and John, A.T., Flexible AC Transmission Systems, IEEE Press (2006).

EEM-201: OPTIMIZATION TECHNIQUES

Credit	L	T	P
4	**3**	**1**	**-**

UNIT- I:

Introduction to optimization, functions of single variable, functions of several variables, formulation of optimization problems. Review of classical methods, linear programming, nonlinear programming.

UNIT-II:

Constraint optimality criteria, constrained optimization, constraint direct search method, linearization methods for constrained problems, transformation method. Nonlinear programming: problem formulation, Quadratic Approximation Methods for Constrained Problems Unconstrained minimization techniques.

UNIT-III:

Dynamic programming: sub-optimization, multistage optimization problem. Multi-objective and goal programming: problem formulation, solution of a multi-objective problem. Case studies

UNIT-IV:

Introduction to Stochastic Optimization Techniques, types: Local Search, Population Based, Introduction to Genetic Algorithms, Motivation from Nature, Genetic Algorithms: Working Principle: Representation, Fitness Assignment, Reproduction, Crossover, Mutation, Constraint Handling, Real Parameter Genetic Algorithms, Combined Genetic Algorithm, Advanced Genetic Algorithms, Applications.

UNIT-V:

Ant Colony Optimization: Introduction, Ant System, Ant Colony System, ANTS, Significant Problems, Convergence Proofs. Discrete Particle Swarm Optimization (PSO): Introduction, PSO Elements: Position and State Space, Objective Function, Velocity, PSO Algorithm, Examples and Results, Applications.

TEXT/REFFERENCE BOOKS

1. Singiresu S. Rao, 'Optimization Techniques', New Age International Publishers.
2. D. P. Kothari and J. S. Dhillon, 'Power System Optimization, Tata McGraw Hill.
3. C. Mohan and Kusum Deep, 'Optimization Techniques, New Age International Publishers.
4. Godfrey C. Onwubolu, B. V. Babu, "New Optimization Techniques in Engineering", Springer-Verlag.
5. Marco Dorigo, Thomas Stützle, "Ant colony optimization", MIT Press.
6. Thomas Wiesi, "Global Opimization Algorithms", ebook. http://www.it-weise.de/.s

EEM-209: POWER SYSTEM DYNAMICS AND STABILITY

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:

Power system stability consideration - Definitions-classification of stability - Rotor angle and voltage stability - Synchronous machine representation - classical model - Load modeling concepts - Modeling of excitation systems - Modeling of prime movers.

UNIT-II:

Transient stability - Swing equation - Equal area criterion - Solution of swing equation - Numerical methods - Euler method - Runge-Kutte method - Critical clearing time and angle - Effect of excitation system and governors - Multi-machine stability - Extended equal area criterion - Transient energy function approach.

UNIT-III:

Small signal stability - State space representation - Eigen values - Modal matrices - Small signal stability of signal machine infinite bus system - Effect of field circuit dynamics - Effect of excitation system - Small signal stability of multi machine system.

UNIT-IV:

Voltage stability - Generation aspects - Transmission system aspects - Load aspects - PV curve - QV curve - PQ curve - Analysis with static loads - Loadability limit - Sensitivity analysis - Continuation power flow analysis - Instability mechanisms - examples.

UNIT-V

Methods of improving stability - Transient stability enhancement - High speed fault clearing - Steam turbine fast valving - High speed excitation systems - small signal stability enhancement - Power system stabilizers - Voltage stability enhancement - Reactive power control.

TEXT/REFFERENCE BOOKS

1. Kundur, P., ‘Power System Stability and control’, McGraw-Hill International, 1st Editions, 1994. (Text Book)
2. Anderson, P.M. and Fouad, A. A., ‘Power System Control and Stability’, Galgotia Publications, New Delhi, 2003.
3. Van Cutsem, T., and Vournas, C., ‘Voltage Stability of Electric Power Systems’, Kluwer Academic Publishers, 1998.
4. AbhijitChakrabarti, D. P. Kothari, A. K. Mukhopadhyay and Abhinandan De, ‘An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems’, PHI Learning Private Ltd., 2010.

EEM-211: SMART GRID TECHNOLOGIES

Credit L T P
4 3 1 -

UNIT-I: Evolution of Smart Grid, old versus new grid, Components of Smart Grid, Challenges and Opportunities, Environmental benefits, Smart Grid solutions, Asset Optimization, Demand Optimization, Distribution Optimization, Smart Meter and Communications, Transmission Optimization, Workforce & Engineering Optimization, Smart Grid benefits, Status of Smart Grid implementation in India -Case Studies.

UNIT-II: Smart Substations, Intelligent Electronic Devices, Substation Automation fundamentals, Architectures, Digital Substation, Application functions, Distribution Automation, Distribution Management Systems, applications

Unit III: Smart Distribution, Demand Response, Distributed Energy Resources, Integration, Energy Storage, Microgrids, Advanced Metering Infrastructure (AMI), Smart Homes, Home area networks, Plugged Hybrid Electric Vehicles

UNIT-IV: Smart Transmission, Wide Area monitoring, Phasor Measurement Unit (PMU), WAMS Application functions, Situational Awareness, Dynamic State Estimation, Voltage & Angle Stability Analysis, Real time network modelling, Data Analytics in Smart Grid

UNIT-V: Smart Grid Communications, OSI Reference Model, TCP/IP Model, SCADA Communications-IEC60870, DNP, Substation Communication-IEC 61850, Standards for Phasor measurements and Data Transfer, IEEE C37.118, IEC 61850-90-5, Time synchronization, AMI-Metering protocols, Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), Zigbee, Z wave, WiFi, WiMax, Security and Privacy Issues.

TEXT/REFFERENCE BOOKS

1. Mini S. Thomas and John Douglas McDonald, “Power System SCADA and Smart Grids” CRC Press-2015.

2. Stuart Borlase, “Smart Grids, Infrastructure, Technology and Solutions, CRC Press-2013

3. James Momoh, “Smart Grid, Fundamentals of Design and Analysis”, IEEE Press, John Wiley & Sons, 2012.

4. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & Sons, 2012.

4. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press-2009.

5. www.ieeexplore.org, Relevant Papers published in IEEE Transactions on Smart Grid, IEEE Innovative Smart Grid Technologies Conference, and other relevant IEEE Transactions & Conferences.

EEM-239: POWER SYSTEM AUTOMATION LAB.

Credit	L	T	P
2	-	-	4

List of experiments

RTDS based Experiments:

Exp.-1: Understating and hands on the Real-time Digital Simulator (RTDS- NovaCor™) hardware architecture.

Exp.-2: Understating and hands on the Real-time Digital Simulator (RTDS- NovaCor™) software (RSCAD FX) architecture.

Exp.-3: To model a Voltage Divider circuit on RSCAD FX and perform Real Time simulation using RTDS- NovaCor™.

Exp.-4: To model a three-phase AC circuit on RSCAD FX and perform Real Time simulation using RTDS- NovaCor™.

Riverbed Modeler experiments

Exp.-1: Design an Ethernet Network and demonstrate its operation to examine its performance under different traffic load.

Exp.-2: Design a Wireless Local Area Network and demonstrate its operation to examine its performance under different load.

Exp.-3: Design a Switched Local Area Network and examine the performance of different implementations of LAN connected by switches and hubs.

Exp.-4: To study how to divide a physical network into a number of separate logical networks using Virtual Local Area Network (VLAN).

Exp.-5: Demonstrate the basics of designing a network, taking into consideration the users, services, and locations of the hosts.

Exp.-6: Design the congestion control algorithms implemented by Transmission Control Protocol (TCP), and compare the performance of the algorithm through the analysis of the simulation results.

EEM-213: DIGITAL POWER SYSTEM PROTECTION

Credit: 4
L T P: 3 : 1 : 0

UNIT-1: Computer Relaying

Relaying Evolution, Disadvantages of Conventional Relays, Computer Relaying Architecture, Performance and Operational Characteristics, Cost/Benefits considerations, Substation Computer Hierarchy.

UNIT-2: Digital Signal Processing in Computer Relays

Signal Conditioning Subsystems, Analog-to-Digital Conversion, Sampling, Digital Filtering in Protection Relays; Time domain, Frequency domain, Types of Digital Filters, Spectral Analysis; Discrete Fourier Transform, Fast Fourier Transform, Walsh Function Analysis.

UNIT-3: Digital Protection Algorithms for Power System Components

Relaying as Parameter Estimation, Transmission Line Protection, Transformer Protection, Generator Protection, Bus Protection, Symmetrical Component Distance Relay, Distribution Over-current Protection.

UNIT-4: Communication Requirements for Computer Relaying

Substation Communication Networks, Bandwidth, Data Rate, End-to-end Delays, Digital Data Transmission, Ethernet in Substation, Fiber Optic Communication, End-to-end Delay Standards for Protection Applications.

UNIT-5: Substation Environment Standards and Recent Developments in Relaying Principles

Substation Environment, Industry Environment Standards, EMI and Countermeasures, Supplementary Equipments in Substation, Travelling Waves in Single-phase and Three-phase lines, Travelling Waves due to faults, Directional wave Relay, Travelling wave Distance Relay, Travelling wave Differential Relay, Fault Location Algorithm.

Text/References Books:

1. Phadke A.G., James S. Thorp, “Computer Relaying for Power System”, John Wiley & Sons Inc., 2006

2. James J. Bruke, “Power Distribution Engineering”, Mark Dekker Inc.

3. John A. T., Salman S. K., “ Digital Protection for Power System”, Power & Energy Series, Issue 15 of IEE power series, ISBN-086341303X, 9780863413032, IET, 1997

4. Singh L. P., “Digital Protection- Protective Relaying from Electromechanical to Microprocess”, New Age International, 2006.

EEM-214: POWER SYSTEM PLANNING AND RELIABILITY

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:

System Planning Introduction, Objectives & Factors affecting to System Planning, Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

UNIT-II:

Reliability Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

UNIT-III:

Generation Planning and Reliability Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods, Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

UNIT-IV:

Transmission Planning and Reliability Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

UNIT-V:

Distribution Planning and Reliability Radial Networks, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed Networks, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Breaker Failure**.**

TEXT/REFFERENCE BOOKS

1. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd. 2. Reliability Evaluation of Power System - Roy Billinton& Ronald N. Allan, Springer Publication.
2. Electricity Economics & Planning – T. W. Berrie, Peter Peregrinus Ltd., London.

Websites

1. www.electricaltutorials.com.
2. www.epsinc.com
3. www.electrical4u.com

EEM-204: MODELING AND SIMULATION

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:

System Models The concepts of a system, System environment, Stochastic activities, Continuous and Discrete Systems, System Modeling, Types of models, Static physical models, Dynamic physical models, Static mathematical models, Dynamic mathematical models, Principles used in modeling.

UNIT-II:

System Simulation The technique of Simulation, The Monte Carlo method, Comparison of simulation and analytical methods, Experimental nature of simulation, Types of system simulation, Numerical computation technique for continuous models, Numerical computation technique for Discrete models, Distributed lag models, Cobweb models, Progress of a simulation study.

UNIT-III:

Probability Concepts in Simulation Stochastic variables, Discrete probability functions, Measures of probability functions, Continuous uniformly distributed random numbers, Random number generators (RNG), multiplicative congruential method, Mixed multiplicative congruential method, Other methods of random number generation.

UNIT-IV:

Basic Queuing Models and Arrival patterns Congestion in Systems, Arrival patterns, Poisson arrival patterns, Exponential distribution, Coefficient of variation, The Erlang distribution, Hyper-exponential distribution, Service times, Normal distribution, Basic queuing models, Short hand notation for queuing and loss models, Queuing disciplines, Measures of queues, Mathematical solutions of queuing problems.

UNIT-V:

Simulation Experiments and Statistical Data Analysis Experiments and Statistical inference, Nature of the problem, Estimation methods, Simulation run statistics, Replication of runs, Elimination of initial bias, Batch means, Regenerative techniques, Time series analysis, autoregressive processes, Validation and Testing of simulation models.

TEXT /REFERENCE BOOKS

1. Gordan G., “System Simulation,” Prentice Hall of India.
2. Chaturvedi, D. K,, “Modelling and Simulation of Systems Using Matlab and Simulink”, CRC Press, 2015 (Indian Reprint-special edition)
3. Kobayashi H., mark B. L., “System Modeling and Analysis,” Pearson Education, Inc, New Delhi.

EEM-215: POWER SYSTEM ANALYSIS

Credit	***L***	***T***	***P***
4	**3**	**1**	**-**

UNIT-I:

Power system security, factors affecting power system security, contingency analysis, linear sensitivity factors, contingency selection, concentric relaxation, calculation of network sensitivity factors. Transmission planning criteria.

UNIT-II:

Power system state estimation. Maximum likely hood weighted least squares estimation, matrix formation. State estimation of an AC network.

UNIT-III:

Detection and identification of bad measurements in state estimation. Network observability. Applications. Dynamic (linear) state estimation using PMU measurements

UNIT-IV:

Economic load dispatch, system constraints, economic dispatch with and without losses, exact transmission loss formula, modified coordination equation, economic scheduling of hydrothermal plants, optimal power flow, multiobjective optimal power flow.

UNIT-V

Economy interchange between interconnected utilities. Interchange evaluation. Power pools, transmission effects and issues

TEXT/REFFERENCE BOOKS

1. Power generation Operation & Control, Allen J. Wood and Bruce Woollenberg, John Wiley & Sons.
2. Transmission planning criteria: CEA manual.
3. PMU Dynamic State Estimation: CEA Manual.
4. POSOCO Operator examination handbook.

EEM- 216 DIGITAL COMMUNICATION

	Credit	L	T	P
	4	**3**	**1**	**-**

UNIT-1

Elements of information theory, Source coding theorem, Huffman coding, channel coding theorem, channel capacity theorem.

UNIT-2

Sampling process, Baseband and bandpass sampling theorems, reconstruction from samples, practical aspects of sampling and signal recovery, TDM.

UNIT-3

Waveform coding techniques, PCM, Channel noise and error probability, DPCM and DM, coding speech at low bit-rates, Prediction and adaptive filters, baseband shaping for data transmission, PAM signals and their power spectra, Nyquist criterion, ISI and eye pattern, equalization.

UNIT-4

Digital modulation techniques: Binary and M-ary modulation techniques, coherent and non-coherent detection, bit v/s symbol error probability and bandwidth efficiency.

Error control coding: Rationale for coding, linear block codes, cyclic codes and convolutional codes, Viterbi codes decoding algorithm and trellis codes.

Spread spectrum codes: Pseudonoise sequences, Direct-sequence and frequency-Hop spread spectrum, signal-space dimensionality and processing gain.

UNIT-5

Data Networks: Communication networks, circuit switching, store-and-forward switching, layered architecture, packet switching, multiple access communication.

REFERENCES:

[1] Data communication and networking: B.A. Forouzan: Tata Mc Graw Hill
[2] Digital communication and design for the real world : Andy batenas (addi son)
[3] Digital communication and design for the real world: S.K.LAR.
[4] Digital communication systems: Kolinbiris.
[5] Analog &digital communication: Roden
[6] Digital communication: Proakis
[7] Telecommunication by : Crane
[8] Telecommunication systems &technology :Michael khalid
[9] Digital &analog communication systems :William E. barre
[10] Electronic communication modulation & Tech: Robert J.schoenbeck.

EEM-307: RESTRUCTURING AND DEREGULATION OF POWER SYSTEM

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:
Open access in electricity sector, types of open access- medium term. Competitive Electricity Market and Balancing Mechanism, Scheduling.

UNIT-II:
Traditional Central Utility Model, Reform Motivations, Separation of Ownership and Operation, Central Dispatch versus Market Solution, Independent System Operator (ISO). Components of Restructured Systems: Gencos, Discos and Retailers

UNIT-III:
Wholesale Electricity Market Characteristics: Central Auction, Bidding, Market Clearing and Pricing, Bilateral Trading, Scheduling, Gaming, Ancillary. Maximalist ISO, Minimalist ISO Model. Deregulation in Distribution.

UNIT-IV:
Role of TP: Vertically Integrated Utility, Three Models of the Electricity Market, For-profit TP. Incentive Rate Design, Priority Insurance Scheme, Transmission Expansion in deregulated Environment. Transmission Owners

UNIT-V:
ISOs, Power Exchange (PX), Scheduling Coordinators. PX and ISO: Functions and Responsibilities, Trading Arrangements: The Pool, Pool and Bilateral Trades, Multilateral Trades, Congestion Management in Open-access Transmission Systems, Open-access Coordination Strategies.

Additional Topic: AGC in market oriented power system

TEXT/REFFERENCE BOOKS

1. Loi Lei Lai, “Power System Restructuring and Deregulation: Trading Performance and Information Technology”, John Wiley & Sons Ltd. [TB]
2. Kankar Bhattacharya etc., Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
3. CERC Regulations on Grand og Connectivity, Medium term Open Access and Long Term Open access; Regulations. [RF]
4. CERC Regulation on Open Access-2008 [CERC Compendium]. [RF]
5. POSOCO Manual on Electricity Market. [RF]

EEM-306: ADVANCED POWER ELECTRONICS

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I

Steady state and switching characteristics of BJT, Power Mosfet, Cool MOS, SITs, IGBT. Series and Parallel Operation. MOSFET Operation: Operating principle , characteristics, Turn on, Turn Off, switching losses, SiC switches..

UNIT-II

Review of Step- down, Step up dc-dc converters, Performance parameters, Converter classifications, Switching mode regulators- Buck, Boost and Buck-Boost, Cuk, SEPIC regulators. DC Power Supplies- SMPS DC Power supplies, Flyback converter, Forward Converter, Push-Pull Converter, Half bridge Converter, Full Bridge Converter,

UNIT-III

Review of Voltage source and current source inverters, PWM strategies- Sinusoidal, Trapezoidal, Staircase, stepped, harmonic injected, delta modulation. Concept of Space Vector, space vector switching. Multilevel Inverters – Diode Clamped, improved diode clamped, flying capacitor, cascaded. Application of Multilevel inverters.

UNIT-IV

Transformer Design, DC Inductor, Magnetic Saturation, Capacitor design and ESR effect, Control Circuits, Stability Analysis of Power supply converters.

UNIT-V

Electromagnetic Interference- Common mode, Differential mode noise, EMI Filter, FCC, IEC Standards, UL standards, Active Power Factor correction, Application of Power Electronics Converters.

Additional topics:

1. Analysis of Converters for different applications
2. Simulation using PSIM

TEXT/REFFERENCE BOOKS

1. Ned Mohan, Undeland, Robin, “Power Electronics, Converters, Application and Design”, John Wiley and Sons. Inc, New York, 2011.
2. P. C. Sen, “Power Electronics” Tata McGraw Hill Book Co., New Delhi.
3. G. K. Dubey, S.R. Doradla, A.Joshi and R.M.K. Sinha, “Thyristorised Power Controllers” Wiley Eastern Ltd., New Delhi.
4. M. H. Rashid, “Introduction to Power Electronics”, Pearson Education India, New Delhi

Websites

- www.nptel.ac.in

EEM-308: TRANSMISSION AND DISTRIBUTION AUTOMATION

Credit	L	T	P
4	**3**	**1**	**-**

UNIT-I:
Overview of transmission system, SCADA in Power systems. AGC, Energy ManagementSystems, FACTS, HVDC, Under Frequency Relay (UFR), df/dt control, Islanding. Regionalgrids, Specifications and details. Functions of the SCADA hierarchical levels in Transmission Master stations.

UNIT-II:
Utility distribution system, Types of distribution feeder configurations; Grid network, radial,loop, grounding, Load and fault characteristics. Distribution transformers and regulators.Application of capacitors for distribution system,. Losses and loss reduction in Distributionsystems. Over voltages in Distribution systems.

UNIT-III:
Introduction to Distribution Automation (DA), Constituents of DA, Feeder automationapplication functions, Outage management, customer information systems, AMI, Distributionload flow & fault location algorithms for distribution system.

UNIT-IV:
Substations, Bus Switching Schemes, Types of substations; GIS, Air Insulated, HV PowerElectronic. Smart Grid; Smart Transmission (WAMS, Smart Distribution, Demand SideIntegration (Demand Response & Demand Side Management), Energy Storage, RenewableSource Integration.

UNIT-V:
Substation integration and automaton, Application functions Interface between substation andautomation. Open systems, architecture functional data paths, new vs existing substations.

TEXT/REFFERENCE BOOKS

1. Power Distribution Engineering: James J. Burke, Marcel Dekker, Inc.
2. Electric Power Substation Engineering John D. Mc Donald CRC Press, , Taylor and Francis
3. Control and Automation of Electrical Power Distribution systems, James NorthcoteGreen, R Wilson, CRC Press, Taylor and Francis.
4. Electric Power Distribution, Automation, Protection and Control, James Momoh, CRC press, Taylor and Francis.

Related Research papers.

EEM-309: EHVAC AND DC TRANSMISSION

Credit	L	T	P
4	3	1	-

UNIT-I:
Introduction to EHV AC and HVDC transmission-Comparison –Economic, Technical performance – Reliability – Limitations for EHVAC and HVDC transmission, Distance problems involved in EHVAC transmission, Modeling of AC and DC Networks, Modeling of DC links, Solution of DC load flow, Per Unit System for DC Quantities, Solution of DC power flow.

UNIT–II:
Principles of HVDC Transmission, Terminal equipments and their controls, Reactive powercontrol. Choice of converter configuration, Modeling and analysis of HVDC converters, Analysis of converters for HVDC System: characteristics and their control, DC Link Control Harmonics and filters, Generation of harmonics, multi-terminal DC system.

UNIT-III:
Protection, Converter Faults, Protection against over currents, over-voltages, HVDC circuitbreakers, Protection by DC reactors, Insulation coordination, Earth return: Use of earth and sea return. Simulation of HVDC Systems: Digital dynamic simulation of converters and DC systems.

UNIT-IV:
Parameters of EHVAC Lines for modes of propagation, resistance and Inductance of groundreturns, Voltage Gradient of conductors Corona effects: Power loss and Audible Noise, Charge-Voltage diagram. Attenuation of traveling waves, Audible noise levels. Power frequency voltage control: Generalized constants, Cascade connection of components-shunt and series compensation. Sub-synchronous Resonance in series- capacitor compensated lines.

UNIT–V:
Origin of overvoltage and their types, short circuit current and circuit breaker. Recovery voltageand the circuit breaker, Overvoltage caused by interruption of inductive and capacitive currents, Ferro resonance over voltage and calculation of switching surges single phase equivalents, Reduction of switching surges on EHV systems.

Additionaltopics:

- Simulation of different power system topologies byPScad& SCADA based softwares

TEXT/REFFERENCE BOOKS

1. BegamudreR.D , "*Extra High Voltage AC Transmission Engineering*", Wiley EasternLtd., Second edition.
2. K.R, Padiyar, *HDVC Power Transmission System*, Wiley Eastern Ltd.
3. E.W. Kimbark, *Direct Current Transmission, Vol*:1 Wiley Interscience.
4. D. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,"*Performance, Operation & Controlof EHV Power Transmission System* ", Wheeler publications.
5. J. Arrillageet. Al *Computer Modeling of Electrical Power System,* John Wiley.

Websites:

- www.nptel.ac.in