CURRICULUM & SYLLABI
2019-2020

M. TECH.
IN
ELECTRICAL POWER SYSTEM MANAGEMENT

M. TECH.
IN
INSTRUMENTATION AND CONTROL SYSTEMS

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

M. TECH. IN ELECTRICAL POWER SYSTEM MANAGEMENT UNDER THE CHOICE BASE CREDIT SYSTEM (CBCS)

Effective from July-2015

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-104Modeling and Simulation /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	Transmission and Distribution Automation	**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 Communication Protocol/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: EEM307 Restructuring and Deregulation of Power System/EEM 306 Advanced Power Electronics **Elective –V:**EEM-308 Smart Grid Technologies/EEM309 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)

M. TECH. IN INSTRUMENTATION AND CONTROL SYSTEMS UNDER THE CHOICE BASE CREDIT SYSTEM (CBCS)

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L Lecture
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I Year

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		
First Semester												
01	EEM-101	Intelligent Techniques	**CBCS**	4	3	1	-	10	15	15	60	100
02	EEM-102	Instrumentation Systems	**DC**	4	3	1	-	10	15	15	60	100
03	EEM-103	Optimal Control Theory	**DC**	4	3	1	-	10	15	15	60	100
04	-	Elective I	**DE**	4	3	1	-	10	15	15	60	100
05	-	Elective –II	**DE**	4	3	1	-	10	15	15	60	100
PRACTICAL (LAB.)												
06	EEM-132	Instrumentation System Lab	**SEC**	2	-	-	4	30	-	-	20	50
			Total	**22**								**550**
Elective –I: EEM-104 Modelling and Simulation/EEM-105 Robotics and Control/EEM-106 Applied Mathematics for Engineers **Elective –II:**EEM-107 Automation Systems/EEM-108 Process Control												
Second Semester												
01	EEM-201	Optimization Techniques	**CBCS**	4	3	1	-	10	15	15	60	100
02	EEM-202	Adaptive and Robust Control	**DC**	4	3	1	-	10	15	15	60	100
03	EEM-203	Transducer Technology	**AECC**	4	3	1	-	10	15	15	60	100
04	-	Elective III	**DE**	4	3	1	-	10	15	15	60	100
05	-	Elective –IV	**DE**	4	3	1	-	10	15	15	60	100
PRACTICAL (LAB.)												
06	EEM-232	Advance Control System Lab	**SEC**	2	-	-	4	30	-	-	20	50
07	EEM-240	Seminar	**SEC**	2	-	-	4	30	-	-	20	50
			Total	**24**							**Total**	**600**
Elective –III: EEM-204 Communication Protocol/ EEM-205 Advance Digital Signal Processing/EEM-216 Digital Communication **Elective –IV:** EEM-206 Smart sensors and Internet of Things/EEM-207 Embedded Systems/EEM-208 Digital Control System												

II Year

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		
Third Semester												
01	-	Elective –V	**SEC**	4	3	1	-	10	15	15	60	100
02	-	Elective –VI	**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 –V: EEM-301Digital Instrumentation/EEM-302 Wireless Sensor Networks **Elective –VI:**EEM-303 Multi Sensor Data Fusion/EEM-304 Biomedical Instrumentation/EEM-305 Non Linear Control System/ EEM-306 Advanced Power Electronics												
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
3	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-102: INSTRUMENTATION SYSTEMS

Credit	L	T	P
3	3	1	-

UNIT-I:
General concepts and terminology of measurement systems: Transfer Function, Span (Full-Scale Input), Full-Scale Output, Accuracy, Calibration, Calibration Error, Hysteresis, Nonlinearity, Saturation, Repeatability, Dead Band, Resolution, Excitation.
First order instruments: time and frequency response characteristics, Second order instruments: time and frequency response characteristics, Standards and calibration of measurement systems.

UNIT-II:
Classifications, working principle, characteristics of various active and passive transducers. Voltage and current transducers, Tap position transducers. Hall effect transducers, optical transducers.
Introduction to semiconductor transducers, fabrication of the semiconductor transducers, and the application of the traducers for physical and chemical parameters measurement**.**

UNIT-III
Design of detection electronics and signal conditioning circuits for various resistive, capacitive, inductive transducers.
Active filters, Impedance matching, loading effect. Introduction to electromagnetic coupling (EMC), inference coupling mechanism, shielding.
Concepts of interface with digital devices like PC, μc, μp.

UNIT-IV
LVDT, Strain gauge and their applications, temperature transducers.
Flow measuring transducers, level measurement. Torque measurement.
Transducers activated RFID tags.

UNIT-V
Controller modes Discontinuous, two positions, multi position, floating control.
Continuous controller modes, proportional, integral, derivative and composite modes of control.

TEXT/REFFERENCE BOOKS
1. Curtis D Johnson, Process Control Instrumentation Technology, Eighth Edition, PHI-2006.
2. Doeblin E.O. Measurement Systems-Application and Design, Fourth Edition, McGrw Hill International Edition, New York-1992.
3. Jacob Fraden , Hand book of Modern Sensors: Physics, Design and applications, publication by Springer
4. Gregory K. McMillan and Doughlas M. Considine, Industrial Instruments and Controls handbook, Tata Mc Graw Hill Edition-2009

EEM-103: OPTIMAL CONTROL THEORY

Credit	L	T	P
3	3	1	-

UNIT I:
Problem formulation – Mathematical model for physical systems like electrical, mechanical translational, rotational and electromechanical systems – Physical constraints for system states and system control - Performance measure as applied to optimal control objectives. Description of minimum time problem, minimum energy problem, minimum control effort and fuel efficiency problem etc.

UNIT II:
Optimal control law – Principle of optimality. An optimal control system. A recurrence relation of dynamic programming – computational procedure. Characteristics of dynamic programming solution. Application of interpolation technique to dynamic programming problems. Hamilton – Jacobi – Bellman equation. Continuous linear regulator problems.

UNIT III:
Fundamental concepts of calculus of variation. Functionals. Piecewise – smooth extremals Constrained extrema. Variational approach to optimal control problems – Necessary conditions for optimal control– Linear regulator problems. Linear tracking problems. Pontryagin's minimum principle and state inequality constraints.

UNIT IV:
Numerical solution of the Riccati equation. Use of linear state regulator results to solve other linear optimal control problems. Sub optimal linear regulators- continuous and discrete time systems. Minimum time problems – Minimum control – effort problems. Singular intervals in optimal control problems.

UNIT V:
Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods Multi stage decision process in discrete time, Multi stage decisio0n process in continuous time – Numerical solution of Two point boundary –value problems. Methods of steepest decent, variation of extremals. Quasilinearization.Gradient projection algorithm. Minimization of functions

TEXT /REFERENCE BOOKS

1. Donald E. Kirk, *Optimal Control Theory: An Introduction*, Prentice-Hall networks series, 1993.
2. Anderson .B. D. O, Moore .J. B, *Optimal control linear Quadratic methods*, Prentice Hall of India, New Delhi, 1991.
3. Sage A. P, White .C. C, *Optimum Systems Control*, Second Edition, Prentice Hall, 1977.
4. D. S. Naidu. *Optimal Control Systems*, (1*e*), CRC Press. 2003
5. B.A Francis, *A course in H∞ control theory, Lecture notes in control and information sciences*, Spriger-Verlag, 1987

EEM-104: MODELING AND SIMULATION

Credit	L	T	P
3	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-107: AUTOMATION SYSTEMS

Credit	L	T	P
3	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
3	**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
3	**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-201: OPTIMIZATION TECHNIQUES

Credit	L	T	P
3	**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-202: ADAPTIVE & ROBUST CONTROL

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

UNIT-I:
System Identification: Introduction, dynamic systems, models, system identification procedure. Simulation and Prediction. Non-parametric time and frequency domain methods. Linear dynamic system identification: Overview, excitation signals, general model structure, time series models, models with output feedback, Convergence and consistency.

UNIT-II:
Parameter estimation: Parameter estimation methods, minimizing prediction errors, linear regressions and Least squares method, Instrumental – variable method, prediction error method. Recursive algorithms. Closed-loop Identification.

UNIT-III:
Adaptive Control: Close loop and open loop adaptive control. Self tuning controller. Auto tuning for PID controllers: Relau feedback, pattern recognition, correlation technique.

UNIT-IV:
Adaptive Smith Predictor control: Auto-tuning and self tuning Smith predictor. Adaptive advanced control: pole placement control, minimum variance control, generalized predictive control.

UNIT-V:
Robust control: Definition and problem statement, the H(n) norm, H∞ norm, frequency domain formulation, state space formulation robust stabilization H2 optimal control, H∞ control.

TEXT/REFFERENCE BOOKS

1. Ljung .L, System Identification: Theory for the user, Prentice Hall, Englewood Cliffs.
2. Astrom .K, Adaptive Control, Second Edition, Pearson Education Asia Pte Ltd.
3. Gang Feng and Rogelio Luzano: Adaptive Control System, Reed Educational and Professional Publishing Ltd 1999.
4. D. S. Naidu. Optimal Control Systems, (1e), CRC Press. 2003
5. B.A Francis, A course in H∞ control theory, Lecture notes in control and Information sciences, Spriger-Verlag, 1987.

EEM-203: TRANSDUCER TECHNOLOGY

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

UNIT-I:
Chemical transducer characteristics, specific difficulties, sensing mechanism, Toxic gas transducer: metal oxide, chemFET, electrochemical transducer, potentiometric, conductometric, amperometric, biochemical, enzyme transducer.

UNIT-II:
Special Transducers: Tactile, Piezoelectric, Mgnetostrictive, Magneto resistive, Electromagnetic transducers, thermo-electric transducer, semiconductor temperature transducer, pH measurement, ultrasonic transducer for viscosity measurement. Transducer arrays, electronic nose, signal processing for electronic nose, smart transducer.

UNIT-III:
Dissolved gas in transformer oil, dissolved gas analysis (DGA), Standards for interpretation of DGA, DGA base fault diagnosis methods: Rogers Ratio Method, Dornenburg's Method, Duval's Triangle Method and soft computing techniques.

UNIT-IV:
Digital Interfacing techniques. Interfaces, processors, code converters, linearizers. Single transmission. Cable transmission of analog and digital signal, fibre optic signal transmission, radio, telemetry, pneumatic transmission.

UNIT-V:
Signal Display/Recording systems. Graphic display systems, storage oscilloscope, recorders: ink, thermal, UV.

Additional topics:

- Microcontroller for digital instrumentation

TEXT/REFFERENCE BOOKS

1. Doeblin E.O. Measurement Systems-Application and Design, Fourth Edition, McGraw Hill International Edition, New Youk-Fifth Edition 2010.
2. Jacob Fraden, Hand book of Modern Sensors: Physics, Design and application, publication by Springer, Fourth Edition 2010
3. Patranabis, D-Sensors and Transducers, Wheeler Pub., New Delhi, 1997.
4. Murthy, D.V.S., Transducers and Instrumentation, PHI, New Delhi.
5. Swobada, G. – Telecontrol: Methods and Applications of Telemetry and Remote Control. Van Nostrand.
6. Newbert, H.K. – Instrument Transducers, Oxford University Press.

Websites

- Analog device, Texas instruments, Honeywell

EEM-204: COMMUNICATION PROTOCOLS

Credit	L	T	P
3	**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-205: ADVANCED DIGITAL SIGNAL PROCESSING

Credit	L	T	P
3	3	1	-

UNIT–I:
Review of Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) and Discrete CosineTransform (DCT). Convolution and Correlation. Time frequency analysis and its need. Short time Fourier Transform.

UNIT-II:
Multi rate digital signal processing: Basic multi rate operations. Efficient structures for decimation and interpolation. Decimation and interpolation and interpolation with polyphase filters. Sampling rate conversion by non-integer factor. Design of practical sampling rate converters. Multi rate filtering applications.

UNIT-III:
Spectrum Estimation and Analysis: Principles of spectrum estimation. Period gram method, modified Period gram methods, the Blackman-Tukey methods, fast correlation method. Autoregressive spectrum estimation: Autoregressive model and filter. Power spectrum density of AR series. Some practical applications.

UNIT–IV:
Adaptive Filtering: Principles of adaptive filtering. Least mean square (LMS) adaptive algorithm its implementation and limitations. Recursive least square (RLS) adaptive algorithm, its implementation and limitations. Basic Wiener filter theory. Applications of adaptive filters in noise cancellations, echo cancellation.

UNIT–V:
Digital Signal Processors: Basic computer architectures for signal processing. General purpose digital signal processors; fixed point digital signal processors and floating point digital signal processors. Implementation of DSP algorithms on general purpose digital signal processors.

TEXT/REFFERENCE BOOKS

1. Emmanuel C. Ifeachor and B. W. Jervice, " Digital Signal Processing", Pearson Education, New Delhi.
1. 2.Li Tan, "Digital Signal Processing" Published by Elsevier Inc., New Delhi.
2. 3.B. Widrow and S. D Stearns, "Adaptive Signal Processing", Pearson Education, New Delhi.
3. 4.Simon Hykins, "Adaptive Filter Theory", Prentice Hall, New Jersey.

EEM-206: SMART SENSORS AND INTERNET OF THINGS

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

UNIT–I:
Environmental parameters measurement and monitoring: why measurement and monitoring are important, effects of adverse parameters for the living being, smart sensors: working principles: different types; selection of smart sensors for practical applications

Unit–II:
Architecture of Smart Sensors: important components, their features, usefulness of silicon technology in smart sensors, fabrication of smart sensors, interface electronic circuit for smart sensors and challenges for interfacing the smart sensor

UNIT-III:
Internet of Things (IoT), vision and challenges for realizing the internet of things, IoT applications, IoT architecture, design,

UNIT–IV:
Design and development of security and privacy technologies related to IoT, design and implementation of IoT for environmental condition monitoring

UNIT–V:
Development of IoT based smart bed for health care application, study of smart city and its design, relevance of IoT to developing world

Additional topics:

- **Wireless sensors nodes and network**

TEXT/REFFERENCE BOOKS

1. G. Meijer, Smart Sensor Systems. Delft, The Netherlands: Wiley, 2008, pp. 240–241
2. S. C. Mukhopadhyay and N. K. Suryadevara, Internet of Things: Challenges and Opportunities, vol. 9. Switzerland: Springer,2014.
3. H. Saha, S. Dey, C. Pramanik, J. Das, and T. Islam, Porous silicon based sensors amenable to smart sensing, in Encyclopedia of Sensors, American Scientific Publishers (ASP), 2006
4. De Marcellis and G. Feri, Analog Circuits and Systems for Voltage Mode and Current Mode Sensor Interfacing Applications. Amsterdam, The Netherlands: Springer, 2011
5. Boby George, Joyanta Kumar Roy, Jagadeesh Kumar and SubhasMukhopadhyay, Advanced Interfacing Techniques for Sensors, Springer-Verlag, Switzerland: Springer,2014

Websites

- Analog device, Texas instruments, Honeywell

EEM-207: EMBEDDED SYSTEMS

Credit	L	T	P
3	3	1	-

UNIT-I:
Introduction to embedded systems: Categories of embedded systems, overview of embedded system architecture, characteristics of embedded systems, quality attributes of embedded systems. Factors to be considered in selecting a microcontroller, recent trends in embedded systems.

UNIT-II:
Custom Single purpose Processor: RT level combinational components, Design implementation of combinational systems using SSI, MSI and PLDs. RT level sequential components, Design and implementation of sequential systems using Flip-flops. RT level Custom single purpose processor design: basic architecture, data path, control unit.

UNIT-III:
Real Time Operating System (RTOS) based Embedded System Design: Operating system basics, Types of operating systems, Tasks, process and threads, Multiprocessing and Multitasking, Task scheduling. Threads, processes and scheduling: putting them altogether. Task communication, Task synchronization, Device Drivers. How to choose an RTOS.

UNIT-IV
Overview of 8051 microcontrollers, Designing with 8051, why 8051 microcontroller, Programming with 8051 microcontroller, different addressing modes supported by 8051 microcontroller., The 8051 instruction sets. Some examples of System design using 8051/8052 microcontroller.

UNIT-V
Introduction to 8051 Timer, Timer SFRs, Timer operating modes, Timer control and operation, using timers as counters, Programming example. 8051 Interrupts, Interrupt sources and interrupt vector addresses, Enabling and disabling of interrupts, Interrupt priorities and polling sequence, Timing of interrupts, Programming examples, 8051 Serial Ports, Serial port control SFRs, Operating modes, Programming serial port, 8051 Interfacing examples.

TEXT/REFFERENCE BOOKS

1. Embedded System Design- A Unified Hardware/ Software Introduction, Frank Vahid and Tony Givargis, John Wiley & Sons.
2. Introduction to Embedded Systems, Shibu K V, Tata McGraw Hill.
3. The 8051 Microcontroller and Embedded systems, Mazidi M L, Mazidi J G, Mckinlay R D, Pearson Education Inc, New Delhi.

EEM-209: POWER SYSTEM DYNAMICS AND STABILITY

Credit	L	T	P
3	**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: TRANSMISSION AND DISTRIBUTION AUTOMATION

Credit	L	T	P
3	**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-214: POWER SYSTEM PLANNING AND RELIABILITY

Credit	L	T	P
3	**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-215: POWER SYSTEM ANALYSIS

Credit	***L***	***T***	***P***
3	**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-301: DIGITAL INSTRUMENTATION

Credit	L	T	P
3	3	1	-

UNIT–I:
Binary counters, Decimal counting units, Decimal counting assemblies, Frequency counters, Counter displays, Period counters, Trigger circuits, Counter errors, Inherent errors, Signal-Related errors, Bistable Elements, Scalers, and Shift Registers, Circuitry of Logic Elements, Digital Voltmeter and multi meter.

UNIT–II:
Introduction, Analog to Digital Conversion Basics, Major Considerations for Data Acquisitions systems, Analog to Digital Converters, ADC performance parameters, ADC code, Sample & Hold circuits, Multiplexing, Digital isolation, Designing of a Data Acquisition system. PC based data acquisition system.

UNIT–III:
IEEE 488 Bus, IEEE 488 devices, IEEE 488 bus signals, Bus Configurations, IEEE 488 controllers, IEEE 488 Software.

UNIT–IV:
Serial communication formats, encoding, modes, Serial RS232 interface, the Universal Serial bus (USB) interface, Microcontroller Serial Interfaces: I2C, SPI, Interfacing switches and sensors; Sensors with digital output and their interfacing.

UNIT–V:
Data loggers, Strain Measurement and Display, Monitoring oscillator stability, PC based industrial measurements like, flow, temperature, pressure and level.

Additional topics:

- Microcontroller for digital instrumentation

TEXT/REFFERENCE BOOKS

1. A.J. Bouwens, *Digital Instrumentation*, Tata McGraw-Hill, 2004.
2. N. Mathivanan, PC-Based Instrumentation, Concepts and Practice, PHI Delhi-110092, 2013
3. Mike Tooley, *PC Based Instrumentation and Control*, Elsevier Butterworth-Heinemann, UK, 2005
4. Joseph J Carr, *Elements of Electronics Measurement & Instrumentation*, Pearson Education, 2008

Websites

- Analog device, Texas instruments, Honeywell, Maxim

EEM-302: WIRELESS SENSOR NETWORKS

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

UNIT-I:
Introduction and overview of Wireless Sensor Networks (WSN), Commercial and Scientific Applications of WSN, Category of Applications of WSN, Challenges for WSN, Enabling Technologies for WSN.

UNIT-II:
Single node Architecture: Hardware Components, Energy Consumption of Sensor nodes, Operating Systems and Execution Environments, Examples of Sensor Nodes, Network Architecture: WSN Scenarios, Optimization Goals and figures of Merits, Design principles for WSNs, Service Interfaces for WSNs, Gateway Concepts.

UNIT-III:
Physical Layer: Wireless Channel and Communication Fundamentals, Physical Layer & Transceiver Design Considerations in WSN, MAC Protocols: Fundamentals, MAC Protocols for WSNs, IEEE802.15.4 MAC Protocol, Routing Protocols: Gossip and agent based unicast protocols, Energy Efficient Unicast, Broadcast and Multicast, Geographic Routing, Transport Control Protocols: Traditional Protocols, Design Issues, Examples of Transport Protocols, Performance of Transport Control Protocols.

UNIT-IV:
Sensor Tasking and Control: Information-Based Sensor Tasking, Joint Routing Information Aggregation, Sensor Network Databases: Challenges, Query Interfaces, In-Network Aggregation, Data Centric Storage, Data Indices and Range queries, Distributed Hierarchical Aggregation, Temporal Data.

UNIT-V:
Operating Systems for Sensor Networks: Introduction, Design Issues, Examples of Operating Systems, Node Level Simulators, Performance and Traffic Management Issues: WSN Design Issues, Performance Modelling of WSNs, Emerging Applications and Future Research Directions.

TEXT/REFFERENCE BOOKS

1. KazemSohraby, Daniel Minoli, TaiebZnati, “Wireless Sensor Networks: Technology,Protocols, and Applications”, Wiley, 2007
2. Holger Karl, Andreas Willig, “Protocols and architectures for wireless sensor networks”,By John wiley& Sons, 2005.
3. Feng Zhao, Leonidas Guibas, “Wireless Sensor Networks: An Information Processing
4. Approach”, Elsevier, 2004
5. C. S. Raghavendra, Krishna M. Shivalingam, TaiebZnati, “Wireless sensor networks”,Springer, 2006.
6. H. Edgar, Jr. Callaway, “Wireless Sensor networks, Architectures and Protocols”, CRCPress, 2004.

EEM-304: BIOMEDICAL INSTRUMENTATION

Credit	L	T	P
3	3	1	-

UNIT-I

Engineering analogy of physiological systems, human body as a control system, development of biomedical instrumentation, Classification of biomedical instruments, source of biomedical signals, components of a biomedical instrumentation system.

UNIT-II

Electrical activity of cell, resting and action potentials, various bioelectric potentials and their waveforms, electrodes, classifications of sensors and transducers, blood pressure measurement, ECG wave and heart rate determination, block and circuit diagram of an ECG machine, measurement of blood flow and cardiac output, fetal monitoring system.

UNIT-III

Electrotherapy, types of defibrillators, diathermy and its techniques, dialysis, endoscopes, theory and types of cardiac pacemakers, heart lung machines, ventilators, infant incubators, anaesthesia machine, drug delivery devices, role of lasers in healthcare.

UNIT-IV

Electroencephalography (EEG), Concept of BCI (Brain control interface): Invasive and Non-invasive Types, EEG Standards, EEG Data Acquisition, detection of physiological parameters using electrical impedance technique, methods of accident prevention/ safety techniques.

UNIT-V

X-rays and radiography, computed tomography, diagnostic ultrasound, Magnetic resonance imaging, electrical impedance tomography, elements of biotelemetry system, functional block diagram of telemedicine, introduction to telesurgery.

Additional Topics:

- Neuroprothesis
- Brain –machine interfaces
- Recent Trends in Neurological Techniques

TEXT/REFFERENCE BOOKS

1. Anandanatarajan R. Biomedical Instrumentation and Measurements. Printice Hall of India (PHI) Learning Pvt. Ltd. Delhi, 2013. ISBN: 978-81-203-4227-9.
2. Raja Rao, C; Guha, S.K. Principles of Medical Electronics and Biomedical. Instrumentation. Orient Longman (Published: 2000), Paperback (Special Indian Edition), 288pp, ISBN: 8173712573.
3. Chatterjee S and Miller A. Biomedical Instrumentation Systems. Cengage Learning India Pvt. Ltd. Delhi, India, ISBN: 13:978-81-315-1953-0, Reprint-2013.
4. Enderle J, Blanchard S, Bronzino J. Academic Press Series in Biomedical Engineering-Introduction to Biomedical Engineering. 2nd Edition, Academic Press: An Imprint of Elsevier, San Diego, California, USA. ISBN: 0-12-238662-0 Reprint-2009.
5. John G. Webster. Medical Instrumentation: Application and design. 3rd Edition, John wiley& sons, 2003.

EEM-306: ADVANCED POWER ELECTRONICS

Credit	L	T	P
3	**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-307: RESTRUCTURING AND DEREGULATION OF POWER SYSTEM

Credit	L	T	P
3	**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-308: SMART GRID TECHNOLOGIES

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

UNIT-I:
Evolution of Smart Grid, Components of Smart Grid, Distributed Energy Resources-Challenges & Opportunity, Microgrid, Active Distribution Systems, Smart Grid benefits, Status of Indian Electricity Systems Markets and Regulations, Grid Modernization Initiatives-Case Studies.

UNIT-II:
Advance Metering Infrastructure (AMI) and Home Area Networks, Distribution Grid Management; Active Distribution Systems, Distribution Management, Substation Automation, Demand Response, Wide Area monitoring, Integration of Distributed Energy Resources (DERs), Electrics Transportation.

UNIT-III:
ISO's OSI 7 layers Reference Model, TCP/IP Model, Zigbee, Z wave, WiFi, WiMax, Substation Communication-IEC 61850, SCADA Communication-IEC60870, DNP, Power Line Communication, AMR, Smart Meter, AMI, Home Area Networks and Technologies, Meter Data Management Systems, Metering protocols, Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), Security and Privacy Issues.

UNIT-IV:
Phasor Measurement Unit (PMU), Standards for Phasor measurements and Data Transfer--IEEE C37.118, IEC 61850-90-5, Time synchronization,

UNIT-V:
Dynamic State Estimation, Voltage Stability Analysis, Angle Stability Analysis, Real time network modeling

TEXT/REFFERENCE BOOKS

1. Mini S. Thomas and John Douglas McDonald, "Power System SCADA and Smart Grids" CRC Press-2015.
2. James Momoh, "SMART GRID Fundamentals of Design and Analysis", IEEE Press, John Wiley & Sons, 2012.
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, 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, Papers published in *IEEE Transactions on Smart Grid*, the *IEEE Innovative Smart Grid Technologies Conference*, and the *IEEE Conference on Smart Grid Communications.*

EEM-309: EHVAC AND DC TRANSMISSION

Credit	L	T	P
3	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