10.12.2016

B.Tech. in Electrical Engineering
Department of Electrical Engineering
(Applicable to Students Admitted during 2016-2017 & onwards)

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
III Semester	EO1323	Economics	3	0	0	3	3	-	30	-	30	40	-
	MA1303 (N)	Engineering Mathematics-III	2	1	0	3	3	-	30	-	30	40	-
	EE1301 (N)	Network Analysis & Synthesis	3	1	0	4	3	-	30	-	30	40	-
	EE1302 (N)	Analog Systems	3	1	0	4	3	-	30	-	30	40	-
	EE1303 (N)	Electrical Machines-I	3	1	0	4	3	-	30	-	30	40	-
	EE1304 (N)	Digital Logic & Design	3	1	0	4	3	-	30	-	30	40	-
	EE1331	MATLAB & Circuits Simulation Lab	0	0	2	1	-	2	-	60	-	-	40
	EE1332	Electronics Lab	0	0	2	1	-	2	-	60	-	-	40
Total			17	5	4	24							

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
IV Semester	CM1403	Value, Ethics & Governance	2	0	0	2	3	-	30	-	30	40	-
	MA1403 (N)	Engineering Mathematics-IV	2	1	0	3	3	-	30	-	30	40	-
	EE1401 (N)	Electrical Measurement & Instrumentation	3	1	0	4	3	-	30	-	30	40	-
	EE1402 (N)	Electrical Machines-II	3	1	0	4	3	-	30	-	30	40	-
	EE1403 (N)	Electromagnetic Field Theory	3	1	0	4	3	-	30	-	30	40	-
	EE149*	Open Elective - I	3	0	0	3	3	-	30	-	30	40	-
	EE1431 (N)	Electrical Machinery Lab I	0	0	2	1	-	2	-	60	-	-	40
	EE1432 (N)	Measurement & Instrumentation Lab	0	0	2	1	-	2	-	60	-	-	40
		Total	16	4	4	22							

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
V Semester	XXXX	Management	3	0	0	3	3	-	30	-	30	40	-
	EE1501 (N)	Control Theory	3	1	0	4	3	-	30	-	30	40	-
	EE1502	Generation, Transmission & Distribution	3	1	0	4	3	-	30	-	30	40	-
	EE1503 (N)	Signals & Systems	3	1	0	4	3	-	30	-	30	40	-
	EE1504 (N)	Power Electronics	3	1	0	4	3	-	30	-	30	40	-
	EE159*	Open Elective – II	3	0	0	3	3	-	30	-	30	40	-
	EE1531(N)	Electrical Machinery Lab II	0	0	2	1	-	2	-	60	-	-	40
	EE1532 (N)	Control & Automation Lab	0	0	2	1	-	2	-	60	-	-	40
Total			18	4	4	24							

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
VI Semester	EE1601 (N)	Microprocessor & Microcontroller	3	1	0	4	3	-	30	-	30	40	-
	EE1602 (N)	Power System Analysis	3	1	0	4	3	-	30	-	30	40	-
	EE1603 (N)	Communication Systems	2	1	0	3	3	-	30	-	30	40	-
	EE165*	Program Elective I	3	0	0	3	3	-	30	-	30	40	-
	EE166*	Program Elective II	3	0	0	3	3	-	30	-	30	40	-
	EE169*	Open Elective III	3	0	0	3	3	-	30	-	30	40	-
	EE1631 (N)	Microconroller Lab	0	0	2	1	-	2	-	60	-	-	40
	EE1632 (N)	Power Electronics & Drives Lab	0	0	2	1	-	2	-	60	-	-	40
		Total	**17**	**3**	**4**	**22**							

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
VII Semester	EE1701 (N)	Power System Protection & Switchgears	3	0	0	3	3	-	30	-	30	40	-
	EE1702 (N)	Power System Engineering	3	1	0	4	3	-	30	-	30	40	-
	EE1703 (N)	Power System Operations & Control	3	1	0	4	3	-	30	-	30	40	-
	EE175*	Program Elective III	3	0	0	3	3	-	30	-	30	40	-
	EE176*	Program Elective IV	3	0	0	3	3	-	30	-	30	40	-
	EE179*	Open Elective-IV	3	0	0	3	3	-	30	-	30	40	-
	EE1731(N)	Power System Lab	0	0	2	1	-	2	-	60	-	-	40
	EE1781	Industrial Training / Seminar	0	0	2	1	-	2	-	60	-	-	40
		Total	**18**	**2**	**4**	**22**							

Teaching Scheme			Contact Hours/Week				End-Term Exam Duration		Relative Weightage %				
No.	Code	Course Name	L	T	P	C	Th.	P.	CWS	PRS	MTE	ETE	PRE
VIII Semester	EE1882	Major Project – I (Practice School/Intrenship)	0	0	0	12	3	-	-	60	-	-	40
			OR										
	EE1883	Major Project-II (In Campus)	0	0	0	8	3	-	-	60	-	-	40
	EE1801	Core/Design Course	3	1	0	4	3	-	30	-	30	40	-
		Total	**3**	**1**	**0**	**12**							

PROGRAM ELECTIVES

Program Elective I

EE 1651	Modern Control Theory
EE 1652	High Voltage Engineering
EE 1653	Renewable Energy Sources
EE 1654	Data Structures & Algorithms
EE 1655	Artificial Intellegence Techniques

Program Elective II

EE 1661	Utilization of Electric Power
EE 1662	FACTS Devices & Their Applications
EE 1663	Distributed Energy Resources
EE 1664	Data Base Management Systems
EE 1665	Modern Optimization Techniques
EE 1666	Solid State Drives

Program Elective III

EE 1751	Computational Techniques in PSA
EE 1752	EHV AC/DC Transmission
EE 1753	Power Quality Issues
EE 1754	Digital Signal Processing

Program Elective IV

EE 1761	Advanced Power System Protection
EE 1762	Power System Restructuring & Deregulation
EE 1763	Smart Grid Systems
EE 1764	Object Oriented Programming

OPEN ELECTIVES

Open Electives I

EE1491	Renewable Energy Sources
EE1492	Network Theory

Open Electives II

EE1591	Energy Conversion Technologies
EE1592	Measurement & Instrumentation

Open Electives III

EE1691	Electrical Energy Systems
EE1692	Industrial Automation & Control.

Open Electives IV

EE1791	Energy Auditing & Management.
EE1792	Solar Photovoltaic Energy Conversion

THIRD SEMESTER

EO1323 ECONOMICS [3 0 0 3]

Economics: Definition, nature and scope of economics. Introduction to micro and macro economics. Law of demand and supply, elasticity of demand and supply. Cardinal and ordinal aproches of utility. Production: Laws of production, cost and revenue analysis in various situations, break-even analysis, capital budgeting. Macro Economics: National income and its concepts, value of money and its changes, foregion exchange rate, momentary and fiscal policies and other macro concepts (Balance of payment, business cycles etc.)

References:

1. P. L. Mehta, *Managerial Economics- Problems and Cases*, Sultan Chand & Sons, New Delhi, 2012.
2. G. J. Tuesen and H. G. Tuesen, *Engineering Economy*, PHI, New Delhi, 2008.

MA1303 (N) ENGINEERING MATHEMATICS III [2 1 0 3]

Vector Calculus Tensor: Gradient, divergence and curl, line, surface and volume integrals, related theorems. Transformation of Co-ordinates: Curvilinear, cylindrical, spherical co-ordinate systems. Complex Variables: C-R equations, conformal mappings, bilinear transformation, Taylor's and Laurent series. Laplace Transforms: Transforms of elementary functions, inverse transforms, convolution theorm. Application of Laplace transforms in the solutions of diffential equeations. Fourier Series: Fourier series, Dirichlet's condition, even and odd functions, half range series, harmonic analysis. Fourier and Z transforms. Fourier Integrals, complex Fourier transforms, Fourier Sine & Cosine transforms, solution of difference equetions using z- transform.

Text Books:

1. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, Delhi, 2006.
2. Srimanta Pal and Subhdh C. Bhunia, *Engineering Mathematics*, Oxford University Press, 2015.
3. H. K. Das, *Advanced Engineering Mathematics*, S. Chand, 2015.

References:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Eastern, 2006.
2. B. V. Ramana, *Higher Engineering Mathematics*, Tata McGraw Hill Education Private Limited, New Delhi, 2007.

EE1301 (N) NETWORK ANALYSIS & SYNTHESIS [3 1 0 4]

Graph Theory: Basics terminology and definitions of network graph- connected and unconnected graph, oriented and oriented graph, concept of tree, co-tree, loop, cut-set, duality etc., network matrices- reduced incidence matrix, basic loop matrix and bacic cut-set matrix, network equestions- node and mesh analysis. Network theorems: Superposition, Thevenin's, Norton's, Maximum power transfer, Reciprocity, Substitution, Compensation, and Millman's theorems. Test Signals and waveforms: Classification of Signals, elementary signals, characteristics, representation of periodic waveforms. Time Domain Analysis: Transient analysis of RL, RC, RLC circuits, initial and final conditions, time domain specification, State variable representation of circuits. Frequency Domain Analysis: Review of Laplace transforms– definition, properties, initial and final value theorems, Laplace transform of standard signals,

analysis of networks by Laplace transform method, concept of complex frequency, network functions, poles and zeros, convolution integral. Two-port network: Two-port parameters, z-, y-, T- and h-parameters, relationship between parameters, inter-connection of two-port networks. Network Synthesis: Hurwitz polynomial, positive real functions, reactive networks, Separation property for reactive networks, specification for reactance function, Foster and Cauer form of reactance networks, synthesis of R-L and R-C networks in Foster and Cauer forms.

References:

1. W. Hayt & J. Kemmerly, *Engineering Circuit Analysis* (6e), Tata McGraw Hill, 2002.
2. F. F. Kuo, *Network Analysis and Synthesis* (2e), Wiley, 1999.
3. V. Valkenberg, *Network Analysis* (3e), PHI Learning Publications, 1990.

EE1302 (N) ANALOG SYSTEMS [3 1 0 4]

Semiconductor Devices: BJT & MOSFET- construction, operations, characteristics, biasing circuits, transistor as an amplifier/ switch, stability of quiescent point. AC Analysis of transistor amplifiers: Transistor at low frequencies, h-parameters, Analysis of a transistor amplifier using h parameters, feedback amplifiers, Oscillators. Power amplifiers: Classification, Analysis and design with respect to efficiency, Series fed and transformer coupled amplifier, thermal run-away, complementary and quasi complementary push-pull amplifier. Operational Amplifier: Applications of operational amplifier-comparators, Schmitt trigger, square wave, triangular wave generators and pulse generator, astable and multivibrator using 555 timer. Active filters: Design of first and higher order low pass, high pass, band pass and band elimination and all pass active filters, voltage controlled filter, self tuning filters.

References:

1. A.S.Sedra & K.C.Smith, *Microelectronics Circuits* (4e), Oxford Univ.Press, 1999.
2. J. Millman and C. C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, Tata Mc-Graw Hill, 1992.
3. F. Sergio, *Design with Op amps & Analog Integrated Circuits*, McGraw Hill, 1997.
4. D. S. William, *Operational Amplifiers with Linear Integrated Circuits*, Prentice Hall, 2004.

EE1303 (N) ELECTRICAL MACHINES-I [3 1 0 4]

Transformers: types, principle, equivalent circuit, O.C and S.C. tests, losses, efficiency and regulation, All-day efficiency, polarity test, Sumpner's test, Cooling, Inrush current phenomenon, Parallel operation, tap changers, Auto-transformers, Connection of single phase transformers for three phase operation, Scott connection, Open delta, three-phase to six phase conversion, Harmonics, Three winding transformer, Three phase induction motors: types, principle, equivalent circuit, windings design, no-load test, blocked rotor tests, circle diagram, cogging and crawling, induction generator, starting, deep bar and double cage motors, Speed control methods – voltage, frequency, rotor resistance, slip power recovery schemes, doubly fed machines, D.C. Generators: Construction, principle of operation, emf equation, types, winding design, armature reaction, commutation, characteristics, D.C. Motors: Principle of operation, types, torque equation, characteristics speed control, starters, testing.

References:

1. M. G. Say, *Alternating Current Machines* (5e), ELBS, 1994.
2. E. H. Langsdorf, *Theory of Alternating Current Machine* (2e), TMH, 1994.
3. A. E. Clayton, *Performance and Design of DC Machines* (3e), O& IBH, 1978

EE1304 (N) DIGITAL LOGIC & DESIGN [3 1 0 4]

Review of Number Systems and Codes: Binary arithmetic, Logic gates and Boolean algebra, De Morgan's theorem, Combinational logic circuits: representation and simplification of logic expressions - Karnaugh map, variable entered map, Quine-McCluskey algorithm, realization using logic gates, Combinational circuit design using Multiplexers, demultiplexers, encoders, decoders, Arithmetic circuits, ALU, Sequential logic circuits: Memory cell, Latches & Flip fops, excitation tables, Ripple counters, Shift registers, Finite state machines, Classification of FSM, analysis and design of FSM, linked state machines, Logic families and their characteristics.

References:

1. J. F. Wakerly, *Digital Design Principles & Practices* (3e), Pearson 2002.
2. D. D. Givone, *Digital Principles & Design*, Tata Mc-Graw Hill, 2003.
3. W. I. Fletcher, *Engg Approach to Digital Design*, Tata Mc-Graw Hill, 1993.

EE1331 (N) MATLAB & CIRCUITS SIMULATION LAB [0 0 2 1]

Module I: Introduction to MATLAB, Electric circuit simulation using MATLAB, script files, data visualization, functions, file I/O and GUI, Introduction to SIMULINK, Steady state analysis of circuits, Transient analysis of RL, RC, and RLC circuits, Circuit simulation using Simscape.
Module II: Electric circuit simulation using PSPICE, Steady state & transient analysis of DC & AC circuits. Modeling and Simulation of electronic devices such as Diodes, BJTs, JFETs, MOSFETs etc. using PSPICE.
Module III: Measurement and experimental verification of network theorems, Evaluation and verification of Two port network parameters.

Text Books

1. D. Hanselman, *Mastering MATLAB 7*, Pearson Education, 2005.
2. M. H. Rashid, *SPICE for circuits and Electronics using PSPICE*, PHI Learning publications, 1995.

EE1332 (N) ELECTRONICS LAB [0 0 2 1]

Module I: Design of fixed and variable voltage power supplies using Zener diodes, voltage regulators IC's 78XX, 79XX, LM317. Design, Simulation and Testing of operational amplifier based circuits such as inverting, non-inverting, summer and filter circuits, 555 timer.
Module II: Design and testing of combinational circuits using gates, multiplexers, decoders, arithmetic circuits etc. Design and testing of sequential digital electronic circuits such as counters, shift registers & sequence generators, sequence detectors etc.

References:

1. J. Millman and C. C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, Tata Mc-Graw Hill, 1992.
2. D. Bell, *Electronic Devices and Circuits* (5e), Oxford University Press.
3. J. Wakerly, *Digital Design: Principles and Practices* (4e), Prentice Hall, Inc, 2005.
4. A. S. Sedra & K. C. Smith, *Microelectronics Circuits* (4e), Oxford Univ.Press, 1999.

FOURTH SEMESTER

CM1403 VALUE, ETHICS & GOVERNANCE [2 0 0 2]

Values: Meaning of value education, Three Gunas, Nature and kinds of value, Understanding Harmony at various Levels: understanding in the human being as co-existence of Self ('I') and Body, in the Self ('I'), understanding myself, harmony with the Body, family, society, Nature, in existence; Ethics and Business: Values and attitude for the professional accountants, Legal frameworks, regulations and standard for business, Nature of ethics and its relevance : Rules based and framework approaches to ethics; personal development and lifelong learning: personal qualities; Ethical principle; concepts of independence, skepticism, accountability and social responsibility, Unethical Conflict: Relationship between ethics, governance, the low and social responsibility, Unethical behavior, Ethical dilemmas and conflict of interest: Organizational Governance: The role and key objectives of organizational governance in relation to ethics and the law; development of organizational governance internationally; the role of directors in relation to organizational governance; the role board. Types of board structure and organizational governance issues, policies and procedure for 'best practice' companies, Rules and principles based approaches to governance.

Text Books:

1. R. R Gaur, R. Sangal and G.P. bagaria, *A Foundation course in Human Values Professional Ethics*, "Excel Books, 2010.
2. S. Sadri & J. Sadri, *Business Excellence through Ethics & Governance*, 2nd edition, 2015.
3. U. C. Mathur, *Organizational Governance and Business Ethics*, MacMillan India Ltd, 2009.

References:

1. C. V. Baxi, *Organizational Governance*, Excel Books, 2009.
2. D. Mehta, Sharma, *Business Ethics and Ethos*, Ramesh Book Depot, 2008
3. R. Namakumari, *Strategic planning of Organizational Strategy*, MacMillan India Ltd, 2010
4. S. Sadri, A. K. Sinha and P. Bonnerjee, *Business Ethiscs: concepts and cases*, TMH, 1998.

MA1403 (N) ENGINEERING MATHEMATICS-IV [2 1 0 3]

Statistics and Probability: Introduction to Probability, Baye's theorem, Measure of central tendency and Dispersion, Random Variables, Expectation, Moments, PMF & PDF. Probabitity distributions: Binomial, Poisson, Normal distribution. Numerical methods: Interpolation and finite difference, Numerical differentiation & integration. Solution of algebraic and transdental equations: Regula-falsi, Newton Raphson, Secant methods. Solution of differential equation: Picard's, Taylor series, Euler's & Eulers Modified Methods, Runge kutta 4^{th} order methods. Solution of system of linear algebraic equations: Gauss elimination, Gauss Jacobi, Gauss Seidel.

Text Books:

1. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, Delhi, 2006.
2. S. Pal and S. C. Bhunia, *Engineering Mathematics*, Oxford University Press, 2015.
3. H. K. Das, *Advanced Engineering Mathematics*, S. Chand, 2015.

References:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Eastern, 2006.
2. B. V. Ramana, *Higher Engineering Mathematics*, Tata McGraw Hill Education Private Limited, New Delhi, 2007.

EE1401 (N) ELECTRICAL MEASUREMENT & INSTRUMENTATION [3 1 0 4]

Basic concepts of measurements: System configuration, calibration - Errors in measurements, Measuring instruments: Permanent magnet moving coil, Moving iron and Electrodynamometer type, Measurement of Circuit Parameters: Low, Medium and High Resistance, Inductance & Capacitance-A.C. Bridges, Instrument Transformers: CT and PT, Transducers: Construction & Operating Characteristics of transducers, Measurement of temperature, pressure, displacement. Oscilloscopes, Analog signal conditioning, Instrumentation amplifiers, v/f and i/f converters, sample and hold circuits, noise cancellation filters , Data conversion: DAC, ADC, Signal transmission: Digital data transmission, Protocols - wired & wireless, Examples - I/O devices and displays, Virtual Instrumentation: Introduction to LabVIEW & its Applications.

Text Book

1. A. K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai & Sons, 2012.
2. E. W. Golding & F. C. Widdis, *Electrical Measurements and Measuring Instruments*, Wheeler, 2011.

References

1. C. S. Rangan, G. R. Sharma & V. S. V. Mani, *Instrumentation Devices and Systems*, Tata Mc-Graw Hill, 1998.

EE1402 (N) ELECTRICAL MACHINES-II [3 1 0 4]

Synchronous machines: Constructional features, e.m.f. equation, suppression of harmonics, Armature reaction: Effect of power factor on armature reaction - Non-salient pole alternator: Synchronous impedance, O.C. and S.C. characteristics – Power input & power output, voltage regulation, Synchronisation:Parallel operation of two alternators, Governor characteristics, alternator connected to infinite bus, Salient pole alternator: Two reaction theory, Blondel's diagram, Phasor diagram, voltage regulation, slip test power angle characteristics, Synchronous motors:Principle of operation, power input and power developed, performance characteristics, O-curve and V- curve, inverted V curve, synchronous condenser, methods of starting - Synchronizing power: Synchronizing power and torque, hunting, periodicity of hunting, damping - Design of electrical machines: Design of main dimensions of transformer & rotating machines – Design of field pole of dc machine & alternator.

References:

1. M. G. Say, *Alternating Current Machinery* (5e), ELBS Publishers, 1994.
2. E. H. Langsdorf, *Theory of Alternating Current Machine* (2e), Tata Mc-Graw Hill, 1994.
3. A. K. Sawhney, *Design of electrical machines,* Dhanpat Rai & sons Publications, 1990.

EE1403 (N) ELECTROMAGNETIC FIELD THEORY [3 1 0 4]

Electrostatics: Coulomb's law – Gauss law and applications, Divergence theorem, Electric scalar potential: Potential gradient, boundary conditions for dielectric materials, capacitance of parallel plate capacitor, co-axial cable, two wire line, Energy density in an electric field, Laplace's and Poisson's equations,Magnetostatics:Biot-Savart's Law and applications, Ampere's circuital law and applications, Curl – Stoke's theorem, magnetic flux and flux density, Magnetic boundary conditions, Inductance – Inductance of toroid, solenoid, two wire line, coaxial cable,Faraday's law:transformer emf, motional emf., Concept of displacement current – Electromagnetic waves, Maxwell's equations in integral and point form, uniform plane wave, wave motion in free space and in conductors, concept of skin depth – Poynting's Theorem and wave power, Reflection of uniform plane waves at normal incidence angle and at oblique incidence angle- Standing wave ratio.

References:

1. W. Hayt, *Engineering Electromagnetics* (7e), Tata Mc-Graw Hill, 2006.
2. J. D. Kraus, *Electromagnetics* (4e), MGH, 1992.
3. K. A. Gangadhar & M. Ramanathan, *Field Theory* (5e), Khanna Publishers, 1982.

EE1431 (N) ELECTRICAL MACHINERY LAB I [0 0 2 1]

OC and SC tests on single phase transformer, Sumpner's test, Polarity tests and connection of single phase transformers as three phase bank, Parallel operation of two single phase transformers, Scott connection of transformers, Open delta connection, Study of harmonics in transformers, tertiary winding, Study of starters for three phase induction motor & DC Motor, No load & blocked rotor tests on three phase IM, Load test on three phase squirrel cage IM, Study of torque-slip characteristics by varying rotor resistance, Load test on induction generator, Magnetization characteristics of DC M/c.

EE1432 (N) MEASUREMENT & INSTRUMENTATION LAB [0 0 2 1]

Module I: Transducers - Operating Characteristics of transducers, Measurement of temperature, pressure, displacement etc., Measurement of power, power factor and pf correction, Three phase power measurement.

Module II: Design & implementation of measurement systems on microcontroller platform - Design starter kit - ASLKv2010.

Module II: Review of Virtual Instrumentation - Comparison of Virtual Instrumentation with Traditional Instrumentation, VI Programming Techniques - Concepts in graphical programming, VIS, Components of VI and sub-VIS, Data Acquisition Basics, Common Instrument Interfaces, Real time Control in VI, Instrument Drivers basics.

References:

1. Hanselman, Mastering MATLAB 7, Pearson Education 2005.
2. S. K.Mitra, DSP: A computer based approach, Tata Mc-Graw Hill, 2006.

OPEN ELECTIVE - I

EE 1491 RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources: Sources and their availability. Solar Energy: Solar radiation and measurements, solar energy storage, Solar Photo-Voltaic systems design. Wind Energy: Wind Energy Estimation, Maximum power and power coefficient, wind energy conversion systems, design considerations and applications. Bio-Mass: Sources of Bio-mass, Bio-mass conversion technologies, Thermo-chemical conversion and Bio-chemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation, Pyrolysis and Liquefaction, Classification of Gasifiers, Energy plantation. Oceans: Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations. Tidal Energy: Origin of tides, Tidal energy conversion systems, Wave energy conversion systems, Hybrid Energy Systems.

Text Books

1. B. H. Khan, Non-conventional Energy Resources, TMH, 2006.
2. J. W. Twidell & A. D. Weir, Renewable Energy Resources, ELBS, 1986.

References

1. D. Mukherjee & S. Chakrabarti, Fundamentals of Renewable Energy Systems, New Age Intl., 2004.
2. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2011.

EE 1492 NETWORK THEORY [3 0 0 3]

Graph Theory: Basics terminology and definitions of network graph- connected and unconnected graph, oriented and oriented graph, concept of tree, co-tree, loop, cut-set, duality etc., network matrices- reduced incidence matrix, basic loop matrix and bacic cut-set matrix, network equestions- node and mesh analysis. Network theorems: Superposition, Thevenin's, Norton's, Maximum power transfer, Reciprocity, Substitution, Compensation, and Millman's theorems. Test Signals and waveforms: Classification of Signals, elementary signals, characteristics, representation of periodic waveforms. Time Domain Analysis: Transient analysis of RL, RC, RLC circuits, initial and final conditions, time domain specification, State variable representation of circuits. Frequency Domain Analysis: Review of Laplace transforms– definition, properties, initial and final value theorems, Laplace transform of standard signals, analysis of networks by Laplace transform method, concept of complex frequency, network functions, poles and zeros, convolution integral.

References:

1. W. Hayt & J. Kemmerly, *Engineering Circuit Analysis* (6e), Tata McGraw Hill, 2002.
2. F. F. Kuo, *Network Analysis and Synthesis* (2e), Wiley, 1999.
3. V. Valkenberg, *Network Analysis* (3e), PHI Learning Publications, 1990.

FIFTH SEMESTER

BB1540 ORGANIZATION AND MANAGEMENT [3 0 0 3]

Meaning and definition of an organization, Necessity of Organization, Principles of Organization, Formal and Informal Organizations. Management: Functions of Management, Levels of Management, Managerial Skills, Importance of Management, Models of Management, Scientific Management, Forms of Ownership, Organizational Structures, Purchasing and Marketing Management, Functions of Purchasing Department, Methods of Purchasing, Marketing, Functions of Marketing, Advertising. Introduction, Functions of Personal Management, Development of Personal Policy, Manpower Planning, Recruitment and Selection of manpower. Motivation – Introduction, Human needs, Maslow's Hierarchy of needs, Types of Motivation, Techniques of Motivation, Motivation Theories, McGregor's Theory, Herzberg's Hygiene Maintenance Theory. Leadership - Introduction Qualities of a good Leader, Leadership Styles, Leadership Approach, Leadership Theories. Entrepreneurship – Introduction, Entrepreneurship Development, Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship, Steps for establishing small scale unit. Data and Information; Need, function and Importance of MIS; Evolution of MIS; Organizational Structure and MIS, Computers and MIS, Classification of Information Systems, Information Support for functional areas of management,

References:

1. Koontz, Harold, Cyril O'Donnell, and Heinz Weihrich: Essentials of Management, Tata McGraw-Hill, New Delhi.
2. Robbins, Stephen P, and Mary Coulter: Management, Prentice Hall, New Delhi
3. E. S. Buffa and R. K. Sarin "Modern Production / Operations Management", 8th Edition, Wiley, 1987.
4. H. J. Arnold and D. C. Feldman "Organizational Behavior", McGraw – Hill.
5. Aswathappa K: Human Resource and Personnnel Management, Tata McGraw Hill.
6. William Wether& Keith Davis, Human Resource and Personnel Management, McGraw Hill

EE1501 (N) CONTROL THEORY [3 1 0 4]

Introduction to Control Theory, Mathematical Models of Electrical: mechanical and electro-mechanical systems, block diagram - signal flow graphs, Mason's gain formula, Time Response: transient response specifications of second order systems , system response with additional pole & zero, Steady state error non- unity feedback systems, Sensitivity Stability: Routh - Hurwitz criterion, frequency domain specifications, Root locus plot transient response design by gain adjustment, Frequency Response Plots: Polar plots, Nyquist stability criterion, stability analysis, Bode plots, Controller Design: Proportional, Derivative and Integral controllers, PI, PD & PID controller, State Model, electrical, mechanical and electromechanical systems, physical variable form and phase variable form.

References:

1. K. Ogata, *Modern Control Engineering (4e)*, Prentice Hall, 2001.
2. Norman S. Nise, *Control Systems Engineering, (3e),* John Wiley & Sons, Inc, 2000.
3. Benjamin C. Kuo, *Automatic Control Systems (9e),* John Wiley & Sons, Inc, 2009.
4. K. R. Varmah, *Control Systems*, Tata Mc-Graw Hill, 2010.
5. M. Gopal, *Control Systems: Principles and Design (4e)*, Mc-Graw Hill, 2012.

EE1502 (N) GENERATION, TRANSMISSION & DISTRIBUTION [3 1 0 4]

Generation of Electric Power: Hydro Electric Power Plants, Thermal and Nuclear Power Plants, Diesel Power Plant, Typical AC transmission and distribution scheme: Effect of system voltage and regulation, Distribution network elements, Transmission Line Parameter Calculations, Transmission Line Performance, Ferranti effect, receiving end power circle diagram, regulated system of transmission by reactive power control, Mechanical design of Overhead lines, Line Insulators, Corona , Underground cables.

References:

1. B. R. Gupta, *Power System Analysis and Design (7e)*, S. Chand Publications, 2014.
2. C. L. Wadhwa, *Electrical Power System (3e)*, New Age Intl., 2000.
3. S. N. Singh, *Electric Power Generation, Transmission and Distribution (2e)*, PHI Learning, 2004.

EE1503 (N) SIGNALS & SYSTEMS [3 1 0 4]

Brief Introduction: Basic definitions, classification, Properties, Sampling and quantization, Time domain analysis of continuous-time and discrete-time signals & systems: linear-time invariant systems, impulse response, convolution, correlation, causality and stability, representation of LTI systems, Frequency domain analysis of continuous time signals and systems: Fourier series, Fourier transform, applications, Frequency domain analysis of discrete-time signals and systems, Discrete-time Fourier series, Discrete-time Fourier transform, Sampling in time domain: reconstruction, discrete-time processing of continuous-time signals, Relation between frequency domain representation in continuous and discrete-domain, Sampling in frequency domain, Discrete Fourier transform: Transform domain analysis of systems, Laplace and Z transform, Representation of systems.

References:

1. S. Haykin, *Signals and Systems (2e)*, Wiley, 2007.
2. A.V. Oppenheim, A.S. Williskyand S.H. Nawab, *Signals and Systems (2e)*, PHI Learning Publications, 1997.
3. R.E.Ziemer, W.H.Tranter&D.R.Fannin, *Signals and Systems (4e)*, Pearson, 2002.

EE1504 (N) POWER ELECTRONICS [3 1 0 4]

Power Semiconductor devices: Power diode, Power Transistor, SCR, Diac, Triac, GTO, Power MOSFET, IGBT – characteristics, safe operating area, device rating, base/gate drive requirements, Commutation techniques of SCRs, Protection of SCR, snubber circuits, R, RC Different firing Circuits of SCR. Converter Topologies: Controlled Rectifiers, Single phase converters - half wave, full wave half controlled and fully controlled bridge converters, Operating mode of Fully controlled bridge converter, Three-phase Converters- half controlled & fully controlled bridge, triggering sequence & operation for different load, effect of source inductance, Line commutated inverters, Single phase and three Phase Dual converters, AC to AC converters: AC voltage regulators, Single Phase Step up and step down, cycloconverter DC – DC Converters: Step down and step up chopper circuit and its operation, Classification of choppers, DC – AC Converters: Single phase half wave and full wave inverter circuit, Three phase bridge inverters 120° & 180° operating mode Square wave operation, PWM control technique of Inverters.

References:

1. D. W. Hart, *Power Electronics (2e)*, Tata Mc-Graw Hill, 2007.
2. Ned Mohan, T. M. Undeland, W. P. Robbins, *Power Electronics, Converters, Applications & Design (3e)*, John Wiley, 2003.
3. M. H. Rashid, *Power Electronics, Circuits, Devices and Applications (4e)*, PHI, 2013.

EE1531 (N) ELECTRICAL MACHINERY LAB II [0 0 2 1]

Predetermination of regulation of alternator by EMF, MMF, and ZPF methods .V- and inverted V-curves of a three-phase alternator, V- and inverted V-curves of a synchronous motor - Measurement of X_d and X_q of a salient pole synchronous machine, Study the Synchronization of an Alternator with an Infinite Bus - Load test on Single Phase induction Motor. Design of main dimensions of Core Type & Shell Type Single Phase Transformer & Rotating Machines.

References:

1. J. B. Gupta, *Electrical Machines (2e)*, S. K. Kataria & Sons, New Delhi, 2013.
2. M. G. Say, *Performance and Design of Alternating Current Machines (3e)*, CBS Publishers, 2002.
3. B. L. Theraja, *A Textbook of Electrical Technology (2e)*, S. Chand, New Delhi, 2009.

EE1532 (N) CONTROL & AUTOMATION LAB [0 0 2 1]

PLC S7 1200: Basics of PLC and its applications, Totally Integrated Automation (TIA) platform. Home Automation and applications, Industrial Automation, Real-time Production Line, Counter. HMI KTP 700 Basics and applications. Real-time Hardware Implementation for different applications with LabVIEW & MATLAB/Simulink. Process Control Trainer Kits with DAQ Cards. Inverted Pendulum & Digital PID Controller.

References:

1. Frank D. Petruzella, *Programmable Logic Controllers (4e)*, Mc Graw Hill Education, 2016.
2. John Essick, *Hands On Introduction to LabVIEW (2e)*, Oxford, 2013.
3. Jerome Jovitha, *Virtual Instrumentation using LabVIEW (2e)*, PHI, 2010.
4. Coughner, *Process Analysis & Control (3e)*, Tata Mcgraw Hill., 1991.

SIXTH SEMESTER

EE1601 (N) MICROPROCESSOR & MICROCONTROLLER [3 1 0 4]

Introduction: Evolution of microprocessors and microcontrollers, memory devices, number system, architecture, interrupts instruction set and assembly language programming of 8085 microprocessor. 8086 Microprocessor: Pin assignments, minimum and maximum mode, architecture, addressing modes, interrupts, instruction format, instruction set and assembly language programming, introduction to 8087 math coprocessor. Peripheral Devices and Their Interfacing: Introduction, memory and I/O interfacing, data transfer schemes, programmable peripheral interface (8255), programmable DMA controller (8257, 8237A), programmable interrupt controller (8259), programmable communication interface (8251), programmable counter/interval timer (8253 and 8254), elements and circuits for interfacing.

Microcontrollers: Architecture, instruction set and assembly language programming of 8051 microcontroller, introduction to 8031/8052 microcontroller. Applications: Measurement and control of electrical and physical quantities, case studies.

References:

1. Ramesh S. Gaonkar, *Microprocessor architecture, programming, and applications with the 8085 (5e)*, Prentice Hall, 2002.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, *The 8051 microcontroller and embedded systems: using Assembly and C (2e)*, Pearson, 2006.
3. Ray A.K. and Bhurchandi K.M., *Advanced Microprocessors and Peripherals (2e)*, Mc Graw Hill Education, 2009.

EE1602 (N) POWER SYSTEM ANALYSIS [3 1 0 4]

Representation of power systems: One line diagram, impedance diagram, per unit notations, selection and change of base quantities, Thevenin's model, equivalent circuit of three-winding transformers. Symmetrical three-phase faults: Short circuit current and reactance of synchronous machines, short-circuit current calculations of unloaded and loaded generators and power systems, selection of circuit breakers, current limiting reactors. Asymmetrical faults: Symmetrical components, Sequence components of line and phase voltages and currents of star-delta transformer banks, sequence impedances and sequence networks of power systems, analysis of unsymmetrical faults in generators and power systems under no-load and loaded conditions, faults through impedances. Stability studies: Steady-state and transient-state stability, swing equation, critical clearing time, Multi machine stability. Load flow studies: Admittance & impedance model for power systems & network calculations. Load flow studies. Load flow solution techniques using Gauss-Siedel method, Newton-Raphson's method.

References:

1. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), Tata McGraw Hill, 2003.
2. I. J. Nagrath & D. P. Kothari, *Modern Power System Analysis (2e)*, Tata McGraw Hill, 1988.
3. H. Saadat, *Power System Analysis (3e)*, McGraw Hill Publications, 2002.

EE1603 (N) COMMUNICATION SYSTEMS [2 1 0 3]

Elements of an Electrical Communication System: Communication Networks, Analog Communication Systems - Principles of Amplitude modulation, double and single side band, suppressed carrier system, AM circuits, AM Transmitters and Receivers, Angle modulation, Frequency modulation, FM receivers, Digital Communication: Sampling theorem, pulse modulation techniques - PAM, PWM and PPM concepts, PCM encoder and decoder, Multliplexing – TDM, FDM - Data communication techniques: Data transmission using analog carriers, MODEMS employing FSK, PSK, DPSK, QPSK, and QAM, error control coding techniques - Multiple Access Techniques, Microwave links, Satellite communication systems, Optical communication systems, Wireless Communication.

References:

1. B. P. Lathi, Zhi Ding and Hari M. Gupta, *Modern Digital and Analog Communication Systems (4e)*, Oxford University Press, 2017.
2. Tomasi W., *Electronics Communications systems (5e)*, Pearson Publications, 2008.
3. Haykin S., *Introduction to Analog and Digital Communications (2e)*, Wiley Publishers, 2012.

4. Theodone S. Rappaport, *Wireless communications: Principles and Practice (2e)*, Pearson Publications, 2010.

EE1631 (N) MICROCONROLLER LAB [0 0 2 1]

Introduction to ESAMCB – 51 kit and Keil software, Programs of Data transfer & Addressing modes, Programs of Data block transfer, Programs of Searching of data in array & sorting of data Array, Programs of Arithmetic & Logical operations, Programs of various Code Conversion techniques, Programs of Delay Generation using timer and counter, Simulation of LCD interface, Simulation of Interrupts Programming on ESA MCB51 Kit, Simulation of Logic Controller Interface, Speed control simulation of Stepper Motor Interface, Simulation of Traffic Light Interface and Elevator Interface, Arduino based motor and LED array interface.

References:

1. M. A. Mazidi, J. G. Mazidi, R. D. McKinlay, *The 8051 microcontroller and embedded systems: using Assembly and C (2e)*, Pearson, 2006.
2. Ramesh S. Gaonkar, *Microprocessor architecture, programming, and applications with the 8085 (5e)*, Prentice Hall, 2002.

EE1632 (N) POWER ELECTRONICS & DRIVES LAB [0 0 2 1]

SCR characteristics : Measurement of latching and holding current, Single Phase Half Wave and Full Wave AC – DC converters, Three Phase Half Wave and Full wave Controlled Converter, AC Voltage Regulator, Cycloconverter controlled Induction machine, Matrix Converter controlled Induction Machine, Open Loop and Closed Loop Speed control of D.C. motor using DSP kit, Open Loop and Closed Loop Speed control of Induction motor using DSP kit, Study harmonics Analysis of Three Phase Power electronic Converter Circuit, Single Phase and Three Phase and Single Phase converter/ Inverter circuit simulation using MATLAB.

References:

1. D. W. Hart, *Power Electronics (1e)*, PHI Learning Publications, 1997.
2. N. Mohan, *Power Electronics, Converters, Applications & Design (3e)*, Wiley, 2002.
3. M. H. Rashid, Power Electronics, Circuits, Devices and Applications (4e), PHI, 2013.

PROGRAM ELECTIVES

PROGRAM ELECTIVES-I

EE1651 MODERN CONTROL THEORY [3 0 0 3]

Introduction to continuous time and discrete time signals: sampling, transfer function of ZOH, Pulse transfer function, Mapping between s-plane and z-plane: Stability criterion in the z-plane, bi-linear transformation, Jury test, stability analysis using root locus and Nyquist plot, State models for continuous-time and discrete-time systems: Solution of state equation for continuous-time systems by time domain & s-domain solutions, state transition matrix, Solution of state equation for discrete-time systems by time domain and z-transform method, discrete-time equivalent of continuous-time systems, Controllability and Observability: Design of continuous time and discrete time systems, Phase lead and phase lag compensation by root locus and by frequency-response methods, pole placement design, Ackermann's formula, design of state observers, Lyapunov stability for continuous-time and discrete-time systems.

References:

1. Brogan and L. William, *Modern Control Theory (3e)*, Pearson education India, 1982.
2. Katsuhiko Ogata, *Modern Control Engineering (5e)*, Pearson education, 1970.
3. Richard C. Dorf and Robert H. Bishop, *Modern control systems (12e)*, Pearson education, 2011.
4. Tripathi, Saurabh Mani, *Modern control systems: An introduction (12e)*, Jones & Bartlett Publishers, 2008.

EE1652 HIGH VOLTAGE ENGINEERING [3 0 0 3]

Breakdown of Gaseous, Liquid And Solid Insulation: Ionisation of Gases, Breakdown Characteristic in gases, Breakdown in Liquids, Commercial liquids, gaseous inclusions, liquid globules, solid particles Breakdown of Solid Insulating Materials, Electro-mechanical, breakdown due to internal discharge, Surface, Thermal, Electro-chemical, Chemical Breakdown, Deterioration, Breakdown of Composite Insulation. Generation of High D.C.& A.C, Voltages and Currents: Halfwave rectifier circuit, Voltage doubler circuits, Cockroft-Walton Voltage multiplier circuit, Electrostatic Generator, VandeGraff Generator, Generation of High AC voltages, Cascaded Transformers, Resonant Transformer, Generation of High frequency AC High voltages, Generation of Rectangular current pulses, Tripping control of Impulse Generator. Definition of Impulse currents & voltages: Impulse voltage Generator, Marx's multi stage voltage generator, Generation of switching surges, definition of impulse current wave forms, impulse current generator. Measurement of High Voltage DC, AC and Impulse Currents & Voltages: Measurement of High D.C. voltages – High ohm series Resistance, Resistance potential Divider, R-C capacitive voltage divider, Generating Voltmeter , Series capacitance voltmeter, CVT, Electrostatic voltmeters, Peak reading a.c. voltmeters (Chubb – Fortescue method), Spherical gaps measurement for High D.C. and AC voltages, Impulse voltage, Measurement of High AC, D.C. and Impulse currents, Hall Generators for D.C. current Measurements, Resistive shunts, Bipolar Strip shunt, Coaxial Tubular shunt, Squirrel cage shunts, C.R.O. for Impulsive voltage and current Measurements. Introduction to various high voltage Testing methods.

References:

1. M.S.Naidu, V.Kamaraju, *High Voltage Engineering (3e),* Tata McGraw Hill-2004.
2. C.L. Wadhwa, High Voltage Engineering (*2e*), New Age International-2007.
3. Zangel & Kuffel, High Voltage Engineering (*2e*), Newnes-2000.

EE1653 RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources and their availability: Solar Energy, solar radiation and measurements, solar energy storage, Solar Photo-Voltaic systems design, Wind Energy estimation, Maximum power and power coefficient, wind energy conversion systems , design considerations and applications,Energy from Bio-Mass: Sources of bio-mass, Bio-mass conversion technologies, Thermo-chemical conversion and Bio-chemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation Pyrolysis and Liquefaction, Classification of Gasifiers,Energy plantation, Geo-Thermal Energy, Energy from the Oceans: Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations,Origin of tides: Tidal energy conversion systems, Wave energy conversion systems, Hybrid Energy Systems.

References:

1. B. H. Khan, *Non-conventional Energy Resources (3e)*, Tata Mc-Graw Hill, 2009.

2. J. Twidell, T. Weir, *Renewable Energy Resources (4e)*, ELBS, 2015.
3. D. Mukherjee, S.Chakrabarti, *Fundamentals of Renewable Energy Systems (1e)*, New Age Intl., 2007.
4. G. D Rai, *Non-Conventioal Energy Sources*, Khanna Publishers, 2004.

EE1654 DATA STRUCTURES & ALGORITHMS [3 0 0 3]

Analysis of algorithms – Stacks: - application to evaluation of postfix expressions, conversion from infix to postfix representation, Queues - Sequential representation, operations, priority queues, and array implementation Linked Lists, Trees ,Graphs ,Sorting – Searching: Greedy techniques - Prim's & Kruskal's algorithms for minimum spanning trees, shortest paths, optimal tape storage, job scheduling with deadlines, Knapsack problem - Divide and Conquer: General technique, maximum and minimum., multiplying long integers, Strassen's matrix multiplication, finding the closest pair of points, Dynamic programming: matrix chain ordering, all pairs shortest paths, optimal BST – Backtracking - NP completeness - Introduction to parallel algorithms.

References:

1. Seymour Lipschutz, *Data Structures (1e)*, McGraw Hill Education India Pvt. Ltd., 2013.
2. Augenstein, Tenenbaum Langsam, *Data Structure Using C & C++ (2e)*, Prentice Hall India Ltd. 2007.
3. Aho, Hopcroft and Ulmann, *Design and Analysis of Algorithms (1e)*, Addison Wesley 2000.

EE1655 ARTIFICIAL INTELLEGENCE TECHNIQUES [3 0 0 3]

Fundamentals of Artificial Neural Networks: Feed forward and feedback networks, learning rules, Single-layer feed forward networks, Multilayer feed forward networks, Linearly non-separable pattern classification, generalized delta learning rule, error back propagation training algorithms, Single layer feedback network, performance analysis of energy function reduction, Application of neural networks. Introduction to Fuzzy control: Inference rules, Fuzzy knowledge based controllers, Fuzzification, membership function evaluation using neural networks, Application of fuzzy logic to control systems: fuzzy-neural systems, Familiarization with MATLAB Fuzzy logic, Genetic Algorithms.

References:

1. M. Zurada Jacek, *Introduction to Artificial Neural Networks (1e)*, West Group, 1992.
2. J. Ross Timothy, *Fuzzy logic with engineering applications (1e)*, McGraw-Hill College, 1995.
3. S. Haykin, *Neural Networks: A Comphrehensive Foundation (1e)*, Indianapolis, IN: Macmillan Publishing Co., 1994.
4. D. E. Goldberg, *Genetic Algorithms in search, Optimization, and Machine Learning (1e)*, Addison-Wesley Professional, 1989.

PROGRAM ELECTIVES-II

EE1661 UTILIZATION OF ELECTRIC POWER [3 0 0 3]

Electric Drives: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, Particular applications of electric drives, Types of industrial loads, continuous, Intermittent and variable loads, load Equalization. Electric Heating: Advantages and methods of electric

heating, resistance heating, induction heating and dielectric heating. Electric Welding: Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding. Electric Traction: System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking-plugging, rheostatic braking and regenerative braking, Mechanics of train movement. Speed-time curves for different services – trapezoidal and quadrilateral speed time curves. Calculations of tractive effort, power, specific energy consumption for given run, effect of varying acceleration and braking retardation, adhesive weight and braking retardation adhesive weight and coefficient of adhesion.

References:

1. C. L. Wadhwa, *Generation, Distribution and Utilization of electrical Energy (3e)*, New Age International (P) Limited Publishers, 2010.
2. N. V. Surya Narayana, *Utilization of Electrical Power including Electric drives and Electric traction (1e)*, New Age International Publishers, 1996.
3. R. K. Rajput, *Utilization of Electrical Power (2e)*, Laxmi Publications, 2016.

EE1662 FACTS DEVICES & THEIR APPLICATIONS [3 0 0 3]

Opportunities for FACTS, types, basic description and definitions, benefits and control attributes, review of voltage sourced converters and self and line commutated current sourced converters, shunt devices: objectives of shunt compensation, SVC, STATCOM, series devices: objectives of series compensation, GCSC, TSSC, TCSC, SSSC, voltage and phase angle regulators: objectives of voltage and phase angle regulation, TCVRs, TCPARs, switching converter based voltage and phase angle regulators, hybrid phase angle regulators, combined compensators: UPFC, IPFC, generalized and multifunctional FACTS devices, application examples of FACTS installations. Basic mathematical modelling of facts devices for steady state and dynamic operation of power system.

References:

1. N. G. Hingorani, and L. Gyugyi, *Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems (1e)*, Standard Publishers Distributors, India, 2000.
2. K. R. Padiyar, *FACTS Controllers in power transmission and distribution systems (1e)*, New Age International publishers, New Delhi, 2007.
3. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, and César Angeles-Camacho, *FACTS: Modelling and Simulation in Power Networks (1e)*, John Wiley & Sons Inc., 2004.

EE1663 DISTRIBUTED ENERGY RESOURCES [3 0 0 3]

Overview of Electric Grid: Distributed Generation, Definition, Need and advantages, Renewable Energy Resources: as DGs, Fuel cell powered DG, Gas Turbine Powered DG, Hybrid System, Energy Storage Systems applicable to DGs, Grid interconnection options, Integration of DERs with grid, Analysis of small Generating systems: Equivalent Models, Generators used with DERS for grid interconnection, Control Techniques for DER integration systems, Standards and codes for interconnection, future structure of grid.

References:

1. H. Lee Willis, W. G. Scott, *Distributed Power Generation- Planning & Evaluation (1e)*, CRC Press, 2000.

2. F.A. Farret, M. Godoy Simões, *Integration of Alternative Source of Energy (1e)*, Wiley InterScience, 2006.
3. M. H. Nehrir, C. Wang, *Modelling and Control of Fuel Cells: Distributed generaion Applicationse (1e)*, Wiley- IEEE Press, 2009.
4. T. Funabashi, *Integration of Distributed Energy Resources in Power Systems: Implementation Operation, and Control (1e)*, Academic Press-Elsevier, 2016.

EE1664 DATA BASE MANAGEMENT SYSTEMS [3 0 0 3]

Database systems - Concepts overview, terminologies, data models - Physical data organization - B-trees, files with dense and sparse index, files with variable length records, look-up on non-key attributes, partial match retrieval, range queries - Network model: DBTG DLL, implementation, operation such as insertion, deletion and modification - Hierarchical model implementation - Hierarchical model architecture, data definition and manipulation in hierarchical database - Relational Model Storage Organization, relational algebra, relational calculus, relational query language, overview of SEQUEL, QUEL, QBE - Design theory for relational database, functional dependencies, decomposition of relational scheme, normalisation - Database protection integrity and security, concurrent operations on database.

References:

1. Elmasri R., Navathe S. B., *Fundamentals of database systems (3e),* Addison Wesley, 2000.
2. Korth H. F., Silberschatz A., *Database system concepts (4e),* MGH, 2002.
3. Ullman J. D., Widom J., *A first course in Database systems (1e),* PH, 1997.

EE1665 MODERN OPTIMIZATION TECHNIQUES [3 0 0 3]

Optimization Fundamentals: Definition- Classification of optimization problems- Unconstrained and Constrained optimization-Optimality conditions- Classical Optimization techniques. Evolutionary Computation Techniques: Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation-GA solution of economic dispatch and unit commitment. Particle Swarm Optimization: Fundamental principle-Velocity Updating-Advanced operators-Hybrid approaches Implementation issues-Solution of OPF problem, Introduction to Modern Optimization Techniques: Ant colony optimization (ACO), Gray Wolf Optimization (GWO), Whale optimization Algorithm. Multi Objective Optimization: Concept of pareto optimality-Conventional approaches for MOOP-Multi objective.

References:

1. Kalyanmoy Deb, *Multi objective optimization using Evolutionary Algorithm,* John Wiley and Sons, May 2001.
2. D.P.Kothari and J.S.Dhillon, *Power System Optimization (2e),* PHI learning Pvt. Ltd., 2011.
3. Carlos A, Coello Coello, Gary B, Lamont, David A., Van Veldhuizen, *Evolutionary Algorithms for solving Multi Objective Problems (2e)*, 2nd Edition, Springer, 2007.
4. Kwang Y. Lee, Mohammed A. El-Sharkawi, *Modern heuristic optimization techniques,* John Wiley and Sons, January 2008.

EE1666 SOLID STATE DRIVES [3 0 0 3]

Electric drives: Components, dynamics, multi-quadrant operation, equivalent moment of inertia, equivalent torque, Components, nature and classification of load torque, Steady state stability, Load equalization,Electric Traction: DC Drives-Single-phase converter fed, Three-phase converter fed, Dual converter fed and Chopper fed DC drives,AC Drives-Induction motor drives: Stator voltage control, static rotor resistance control, Slip power recovery scheme, Frequency control, Constant torque, constant power operation, Field-oriented control, Direct torque & flux control,Synchronous motor drives: Permanent magnet synchronous machine control, Synchronous reluctance machine control, current vector control, Wound field synchronous machine drives, brushless DC excitation,Load commutated inverter drives Switched reluctance motor drives, Power conditioners and un-interruptible power supplies.

References:

1. G. K. Dubey, *Power Semiconductor Controlled Drives (2e)*, Alpha Science International, 2001.
2. S. B. Dewan, G. R. Slemon, A.Straughen, *Power Semiconductor Drives (1e)*. Wiley Publications, 1984.
3. J. M. D. Murphy, F.G.Turnbull, *Power Electronic Control of AC motors (1e)*, Pergamon Publications, 1990.

OPEN ELECTIVES

OPEN ELECTIVES-II

EE1591 ENERGY CONVERSION TECHNOLOGIES [3 0 0 3]

Fundamentals of Energy Conversion: Classification of Energy Sources- Conventional & Renewable Energy, Principle fuels for energy conversion- Fossil fuels and Nuclear fuels, Nature of Energy Sources and their peculiar characteristics, Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, Nuclear energy etc., Energy Conversion through fission and fusion, Nuclear power generation etc. Conversion of Thermal, Electromagnetic and Mechanical energy into electricity. Electrical Energy Sources: Importance of Electrical energy in modern industrial society-its relative advantages and disadvantages, Production of electricity using coal, oil, natural gas, nuclear fuels and hydel, Conversion of Thermal, Nuclear, hydel energy into electric energy, Conversion of Electromagnetic energy and natural energy sources like solar radiation, Wind, Ocean waves, Solid waste. Electrical and Other Energy Utility Systems.

References:

1. A. W. Culp, *Principles of Energy Conversion (2e)*, McGraw-Hill Education, 1991.
2. M. A. Kettani, *Direct Energy Conversion (Electrical Engineering) (1e)*, Addison-Wesley Educational Publishers, 1970.
3. R. D. Begamudre, *Energy Conversion Systems (1e)*. New Age International Publisher, 2000.
4. W. R. Corliss, *Direct Energy Conversion (1e)*, U.S. Atomic Energy Commission, Division of Technical Information, 1964.
5. B. K. Hogde, R. P. Taylor, *Analysis and Design of Energy Systems (3e)*, Pearson, 1999.

EE1592 MEASUREMENT & INSTRUMENTATION [3 0 0 3]

Basic concepts of measurements: System configuration, calibration - Errors in measurements, Measuring instruments: Permanent magnet moving coil, Moving iron, Electrodynamometer type, Measurement of

Circuit Parameters: Low, Medium and High Resistance, Inductance & Capacitance-A.C. Bridges, Transducers, , Analog signal conditioning, Instrumentation amplifiers, sample and hold circuits, noise cancellation filters , Data conversion: DAC, ADC, Signal transmission: Digital data transmission, Oscilloscopes Measurements using CRO.

References:

1. A. K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation (4e)*, Dhanpat Rai & Sons, 1991.
2. E. W. Golding, F. C.Widdis, *Electrical Measurements and Measuring Instruments (5e)*, Wheeler, 1989.
3. C. S. Rangan, G. R. Sarma, V. S. V. Mani, *Instrumentation Devices and Systems (2e)*, Tata Mc-Graw Hill, 1998.

OPEN ELECTIVES-III

EE 1691 ELECTRICAL ENERGY SYSTEMS [3 0 0 3]

Global Energy Scenario: Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Indian Energy Scenario: Energy resources & Consumption: Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption Electrical Energy Sources: Diesel Power Plant , Hydro Electric Power Plants , Gas turbine power plant , Applications Combined operation of power plants, load division among different types of power plants, Renewable Energy: Solar, Wind, Biomass, Geothermal, tidal, Fuel Cell Introduction to transmission and distribution systems. Protection of electrical systems.

References:

1. M. A. El-Sharkawi, *Electric Energy an Introduction (2e)*, CRC Press, 2008.
2. C. E. Brown, *World Energy Resources (1e)*, Springer, 2002.
3. V. Balzani, N Armanroli, *Energy for a Sustainable World (1e)*, Wiley-VCH, 2011.

EE1692 INDUSTRIAL AUTOMATION & CONTROL [3 0 0 3]

Architecture of Industrial Automation Systems - sensors and measurement systems: Signal Conditioning and Processing, Estimation of errors and Calibration,Process Control Controller Tuning, Implementation of PID Controllers, Special Control Structures,Sequence Control: PLCs and Relay Ladder Logic, Scan Cycle, RLL Syntax, Structured Design Approach, Advanced RLL Programming, PLC, Hardware environment: Control of Machine tools, Analysis of a control loop, Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems, Integrated Control Systems, Networking of Sensors, Actuators and Controllers.

References:

1. K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai & Sons, 2005.
2. G. K. Dubey, *Power Semiconductor Controlled Drives*, PH, 1989.
3. S. Nise Norman, *Control Systems Engineering*, John Wiley & Sons, Inc, 2000.

SEVENTH SEMESTER

EE1701 (N): POWER SYSTEM PROTECTION & SWITCHGEAR [3 0 0 3]

Protective Relaying: Functional characteristics, standard definition of relay terminologies, classifications & operating principles, Feeder Protection, Distance Protection, Generator Protection, Transformers Protection, Translay Relay, Carrier Current Protection, Comparators, Static Relays, Digital Protection, Linear Couplers, Current Transformers, Potential Transformers. Circuit breakers: Arc phenomenon, arc interruption theories, Current chopping. CB types: Oil circuit breakers, Air circuit breakers, SF6 CB, Vacuum CB, MCB, MCCB, ELCB, RCCB and HVDC circuit breakers. CB rating, testing, operating mechanism, Autoreclosure, metal clad switchgear, Isolators and earthing switches, Fuses, Neutral grounding.

References:

1. S. S. Rao, *Switchgear Protection and Power systems*, Khanna Publishers, 2015.
2. B. Ram and D. N. Vishwakarma, *Power System Protection & Switchgear*, MGH, 2014.
3. B. Ravindranath and M. Chander, *Power System Protection and Switchgear*, New Age International, 2018.
4. R. P. Singh, *Digital Power System Protection*, PHI, 2007.

EE1702 (N): POWER SYSTEM ENGINEERING [3 1 0 4]

Economic Operation of Power Systems: Introduction, system constraints, optimal operation of power systems. Input output, heat rate and incremental rate curves of thermal generating units. Economic distribution of load between generating units within a plant. Economic distribution of load between power stations, transmission loss equation. Introduction to unit commitment and dynamic programming. Power System Stability-I: Power angle equations and power angle curves under steady state and transient conditions. Power System Stability-II: Introduction to transient stability. Equal area criterion and its application to transient stability studies under basic disturbances. Critical clearing angle and critical clearing time. Factors affecting stability and methods to improve stability. Excitation Systems: Introduction of excitation systems of synchronous machines, types of excitation systems, Elements of various excitation systems and their control (functional block diagrams and their brief description)-DC excitation systems, AC excitation systems, brushless excitation system. Interconnected Power Systems: Introduction to isolated and interconnected powers systems. Reserve capacity of power stations, spinning and maintenance resaves. Advantages and problems of interconnected power systems.

References:

1. I. J. Nagrath and D.P. Kothari, *Power System Engineering* (2e), MGH. 2011
2. J. J. Grainger and W. D. Stevenson, *Power System Analysis*, MGH. 2003
3. B. R. Gupta, *Power System Analysis and Design* (3e), S. Chand & Co. 2008.
4. C. L. Wadhwa, *Electrical Power Systems* (3e), New age international Ltd., 2009.

EE1703 (N): POWER SYSTEM OPERATION & CONTROL [3 1 0 4]

Basic introduction to power system operations and control: The structure of modern electrical power system, Operating states of power system, Basic power system control and objectives - generating unit controls. Automatic Generation Control (AGC): Basic generator control loops, automatic load frequency control (ALFC), Mathematical modelling of turbine speed-governing system, steam turbine model and generator load model, complete block diagram representation, stead-state and dynamic analysis, Concept of control area- single and two area control, proportional-integral controller. Automatic Voltage Regulator (AVR): basic control loop, block diagram representation- exciter system, generator models, stability of excitation system. Reactive Power & Voltage Control: Necessity of voltage control, generation and absorption of reactive power, methods of reactive power/voltage control, reactive power flow and voltage collapse, concept of voltage stability, synchronous generator capability curve, reactive power compensation- series & shunt compensation, basic introduction to Flexible AC Transmission Systems (FACTS). Introduction to Economic Operations: Basics formulations of Economic Load Dispatch (ELD) and Unit Commitment (UC).

References:

1. P. Kundur, *Power System Stability Analysis & Control*, Tata Mc Graw Hill, 2006.
2. A. Wood & B. F. Woolenberg, *Power System Operation & Control*, John – Wiley, 2003.
3. S. Sivanagaraju & G. Sreenivasan, *Power System Operation and Control*, Pearson, 2013.
4. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), Tata McGraw Hill, 2003.
5. D. P. Kothari & I. J. Nagrath, *Modern Power System Analysis* (2e), TMH, 2013.

EE1731 (N): POWER SYSTEMS LAB [0 0 2 1]

Module-I (Software based): YBUS and ZBUS formulation, Load flow study Newton-Raphson (N-R) and Fast Decoupled Load Flow (FDLF) Methods, Short Circuit Study, Contingency analysis, Optimal system operation & Unit Commitment, Transient stability analysis, Reactive power control and voltage stability, Simulations on MATLAB and DIgSILENT – Power Factory Software. Module-II (Hardware based): Over current protection using numerical relay- high set & low set protection, relay characteristics, over/under voltage protection, Motor protection feeder, Transformer protection, Generator protection, fault analysis: symmetrical and unsymmetrical faults, Transmission line performance evaluation, standalone and grid tied solar PV system.

References:

1. D. P. Kothari & I. J. Nagrath, *Modern Power System Analysis* (2e), TMH, 2013
2. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), TMH, 2003.
3. H. Saadat, *Power System Analysis*, MGH, 2011.
4. G. J. Duncan, *Power System: Analysis & Design*, Cengage Learning, 2012.

EE 1881: INDUSTRIAL TRAINING / SEMINAR [0 0 0 1]

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of sixth semester. Student has to submit to the department a training/tour report in the prescribed format. The report should include the certificates issued by the industry. Student has to give a seminar in the form of a PPT presentation on the industrial training and associated area of work.

EIGHTH SEMESTER

EE1882: MAJOR PROJECT – I (PRACTICE SCHOOL / INTERNSHIP) [0 0 0 12]

The major project/internship work may be carried out (outside MUJ) in reputed industry/ research laboratory or any other competent institutions. The duration of the said major project/internship shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation shall be done after about 8 weeks based on interim project report on the progress of the work as submitted to the department for mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the departmental committee as part of project evaluation.

OR

EE1883: MAJOR PROJECT- II (IN CAMPUS) [0 0 0 8]

The major project work (in-house) may be carried out under the supervision of a faculty member assigned by the department. The duration of the said major project shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation shall be done after about 8 weeks based on PPT presentation and mid-term project report on the progress of the work as submitted to the department for mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the departmental committee as a part of project evaluation.

EE1801: CORE/DESIGN COURSE [0 0 0 4]

For the students pursuing in-house project work as EE1883: MAJOR PROJECT- II, it is desirable to complete a 04 credit core / design course related to the project area as suggested or recommended by the supervisor.

PROGRAM ELECTIVE III

EE1751: COMPUTATIONAL TECHNIQUES IN POWER SYSTEM ANALYSIS [3 1 0 4]

Review of Power System Components: Network Matrices, Bus Impedance matrix, admittance matrix formation and modification of bus impedance matrix in three phase networks, Short Circuit Studies, symmetrical and asymmetrical faults: ZBUS and YBUS matrices for short circuit studies, short circuit calculations using ZBUS, symmetrical component analysis: calculation of currents and voltages, load Flow Studies: PQ, PV and slack buses, bus mismatch, Gauss-Seidal, Newton-Raphson and Fast Decoupled methods of load flow analysis, Stability Studies: Transient Stability, Swing equation, synchronous machine and induction machine equations, representation of load, modified Euler and Range-Kutta methods of transient stability analysis.

References:

1. M. A. Pai, *Computer Techniques in Power System Analysis*, (2e) Tata McGraw-Hill, New Delhi, 2005.
2. H. Saadat, *Power System Analysis*, TMH, 2004.
3. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), TMH, 2003.
4. E. V. Krishnamurthy and S. K. Sen, *Computer Based Numerical Algorithms*, East-West Press, New Delhi, 2008.

EE1752: EHV AC/DC TRANSMISSION [3 0 0 3]

EHV AC Transmission: Need of EHV transmission lines, power handling capacity and surge impedance loading, traveling and standing waves. Problems associated with EHV transmission, Electrostatic fields of EHV lines and their effects, Radio and TV interference due to EHV AC systems and methods to reduce interference. Load Frequency Control: Introduction to control of active and reactive power flow, turbine speed governing system. Speed governing characteristic of generating unit and load sharing between parallel operating generators. Method of Load Frequency Control: Flat frequency, flat tie line and tie line load bias control. Voltage Control: Power circle diagram and its use, Voltage control using synchronous condensers, Cascade connection of shunt and series compensation, Sub synchronous resonance, Compensated lines, Static VAR compensating system – TCR, FC-TCR and TSC- TCR. HVDC Transmission: Types of D.C. links, advantages and disadvantages of HVDC transmission. Converter configurations and their characteristics, DC link control, converter control characteristics, Ground return, Application of HVDC transmission.

References:

1. R. D. Begamudre, *EHV AC Transmission Engineering* (4e), New Age International, 2014.
2. K. R. Padiyar, *HVDC Power Transmission Systems* (3e), New Age Publishers, 2017.
3. E. W. Kimbark, *Direct Current Transmission Vol-I* (1e), John-Wiley Interscience,1971.
4. J. Arrillaga, *High voltage Direct Current Transmission* (2e), IET, 1998.

EE1753: POWER QUALITY ISSUES [3 0 0 3]

Power Quality Issues: Standards and indices, Voltage sags, swell, surges, spikes, Interruptions, Harmonics: harmonic distortion of fluorescent lamps, effect of power system harmonics on power system equipment and loads, Power factor improvement, Passive Compensation, Passive Filtering, Harmonic Resonance, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter-static var compensators, SVC and STATCOM, Active Harmonic Filtering: Shunt Injection Filter for single phase , three-phase three-wire and three-phase four-wire systems, UPS, constant voltage transformers, series active power filtering

techniques for harmonic cancellation and isolation, Dynamic Voltage Restorers, Grounding and wiring, NEC grounding requirements, solutions to grounding and wiring problems.

References:

1. S. Santoso, H. W. Beaty, R. C. Dugan, M F. McGranaghan, *Electrical Power System Quality*, Second edition, McGraw Hill Pub, 2002.
2. H. B. Math, *Understanding Power Quality Problems*, IEEE Press, 1st Edition, 2001.
3. J. Arrillaga, *Power System Quality Assessment*, John Wiley, 2000.
4. A. Ghosh and G. Ledwich, *Power Quality Enhancement using Custom Power Devices*, Kluwer Academic Publication, 2002.
5. C. Shankran, *Power quality*, CRC Press, 2001.

EE1754: DIGITAL SIGNAL PROCESSING [3 0 0 3]

Time domain analysis of discrete-time signals & systems: linear-time invariant systems, impulse response, convolution, causality and stability, representation of LTI systems, Frequency domain analysis of discrete-time signals and systems: Discrete-time Fourier series, Discrete-time Fourier transform, properties and applications, Z transform representation of discrete time signals and systems, properties and applications. Sampling in time and frequency domain. Discrete Fourier Transform-Linear convolution using DFT. Computation of DFT-Fast Fourier Transform, Decimation in time and Decimation in frequency FFT algorithms. Digital Filters-Digital filter structures, FIR and IIR filters. FIR filter design- FIR design by Fourier approximation, Window method, Frequency sampling method, Optimal FIR design. IIR filter design: Classical filter design using Butterworth and Chebyshev approximations, Impulse invariant and bilinear transformation methods, Frequency transformation technique for HP, BP and BS filter design. Direct design of IIR filters. Applications of DSP.

References:

1. S. Haykin, *Signals and Systems*, Wiley, 2007.
2. A. V. Oppenheim, Alan S. Willsky, and S. H. Nawab, *Signals and Systems* (2e), PHI, 2014.
3. J. G. Proakis and D. G. Manolakis, *Introduction to Digital Signal Processing*, PHI, 2009.
4. A. V. Oppenheim and R. W. Schafer, *Discrete time signal processing*, Pearson, 2009.
5. S. K. Mitra, DSP: A computer based approach (2e), TMH, 2006.

PROGRAM ELECTIVE IV

EE1761: ADVANCED POWER SYSTEM PROTECTION [3 0 0 3]

Static Relays: Advantages of static relays, Basic construction of static relays, Level detectors Mixing circuits, Amplitude Comparators, Phase Comparators, Static Over Current Relays, Static Differential Relays, Microprocessor Based Protective Relays: Over current relays, impedance relays, directional relay, Reactance relay, Generalized mathematical expressions for distance relays, measurement of resistance and reactance, MHO and offset MHO relays – Realization of MHO characteristics, Realization of offset MHO characteristics, Basic principle of Digital computer relaying, Digital Relaying Algorithms.

References:

1. J. L. Blackburn, *Protective Relaying: Principles and Applications*, CRC Press, 2006.
2. R. P. Singh, *Digital Power System Protection*, PHI, 2007
3. B. Ram and D. N. Vishwakarma, *Power System Protection & Switchgear*, MGH, 2014.
4. T. S. Madhav A. Rao, *Static relays* (2e), TMH, 1989.

EE1762: POWER SYSTEM RESTRUCTURING & DEREGULATION [3 0 0 3]

Introduction to Restructuring of Power Industry: Basic Terminology- Restructuring, Competition and Deregulation, Deregulation of power industry, Restructuring process, Issues involved in deregulation-Causes, Types and Effects of Restructuring, Deregulation of various power systems. Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long run costs, various costs of production, Types of Market Environments. Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity and other commodities,

Market architecture, Role of the Independent System Operator (ISO), Operational planning activities of ISO- ISO in Pool markets, ISO in Bilateral markets, Transmission Congestion Management and Pricing: Power wheeling, Transmission open access, Transmission Pricing Schemes, Transmission Cost Allocation Methods of congestion management in deregulation. Ancillary Services Auction Market: General description of various ancillary services, ancillary services management in various countries, and reactive power management in the deregulated electricity markets.

References:

1. K. Bhattacharya, M. Bollen and J. C Daalder, *Operation of Restructured Power Systems*, Kluwer Academic Publishers, USA, 2001.
2. M. Shahidehpour, H. Yamin and Z. Li, *Market Operations in Electric Power Systems- Forecasting, Scheduling, and Risk Management*, John Wiley & Sons, Inc., New York; 2002.
3. D. Kirschen and G. Strbac, *Fundamentals of Power System economics*, John Wiley & Sons Ltd, 2004.
4. C. Harris, *Electricity Markets: Pricing, Structures and Economics*, John Wiley & Sons Ltd, 2006.

EE 1763: SMART GRID SYSTEM [3 0 0 3]

Smart Grid Overview- Smart Grid evolution, Definition of the Smart Grid, Key Characteristics of Smart Grid, Key Functions of a Smart Grid, Smart Grid Elements. Traditional Electric Grid Model, Generation, Transmission, Distribution, Energy Storage, Micro-grids, Integration of new technologies into the grid, Smart Grid vision and its realization in Urban/Rural, Smart Grid infrastructure, Functionality, Reliability, Cost/Tariff, Standards, Smart Grid cyber security, Smart Grid Operations- Electric Grid (power delivery), SCADA (supervisory control and data acquisition), Smart Grid Control Layer-fault detection and location, Data collection and management, Control Layer Infrastructure, Software-Define Networks (SDN), Control Algorithms, Volt-VAR control, Distribution automation, Grid storage systems, Intermittent renewable, Cooperative grids.

References:

1. J. Momoh, *Smart Grid: Fundamentals of Design and Analysis*, IEEE press, John Wiley & Sons, 2012.
2. T. Sato, Daniel M. Kammen, B. Duan, M. Macuha, Z. Zhou, and Jun Wu, *Smart Grid Standards: Specifications, Requirements, and Technologies*, Wiley-Blackwell, 2015.
3. J. Ekanayake, K. Liyanage, Jianzhong Wu, A. Yokoyama, and N. Jenkins, *Smart Grid: Technology and Applications*, Wiley, New Delhi, 2015.
4. L. T. Berger and K. Iniewski, *Smart Grid Applications, Communications, and Security*, Wiley, New Delhi, 2015.
5. K. Salman, *Introduction to the Smart Grid: Concepts, Technologies and Evolution*, The Institution of Engineering and Technology, United Kingdom, 2017.

EE1764: OBJECT ORIENTED PROGRAMMING [3 0 0 3]

Introduction to fundamental concepts of programming language, Object Oriented Programming paradigm, Characteristics of object oriented languages. Classes and Objects: Class specification, Class objects, Accessing Class Members, Static members, Constructors and Destructors, Parameterized constructors, Multiple Constructors, Friend function. Operator Overloading & Type conversion: Defining operator overloading, Overloading Unary and Binary operators, Overloading using friend function, Type conversion: Basics to class type, class to basic type and class to another class type. Inheritance: Derived class and base class, Types of inheritance, Levels of Inheritance, Single inheritance, Multiple Inheritance, Hierarchical inheritance and Hybrid inheritance. Polymorphism: Virtual Functions: Pure function, Friend classes. Files and Exception Handling: Classes for file stream operation, Opening and closing a file, file modes, file pointers and manipulators. Exception handling mechanism: throwing, catching all the exceptions.

References:

1. J. Rumbaugh et. al, "Object Oriented Modeling and Design", PHI, 2004

2. E. Balagurusamy, "*Object Oriented Programming with C++*", (6e), Tata McGraw-Hill Education Pvt. Ltd, New Delhi, 2013.
3. R. Lafore, "*Object Oriented Programming in Turbo C++*", (3e), Galgotia Publications Pvt. Ltd., New Delhi, 2006
4. S. B. Lippman, Josee Lajoie, Barbara E Moo, "*C++ Primer*",(5e), Addison-Wesley Professional, 2012
5. H. Schildt, "*The Complete Reference C++*", (4e), TMH, New Delhi, 2004

OPEN ELECTIVE III

EE1791: ENERGY AUDITING & MANAGEMENT [3 0 0 3]

Energy Types, Needs, Scenario, Energy Security, Environmental Impact, Energy Reforms, Material & Energy Balance, Consumption Pattern, Sankey Diagram, Energy Policy, Information Systems, Energy Conservation Act 2001, Electricity Act 2003, Energy Reforms, National Action Plan for Climate Change (NAPCC), Standards & Labels , Energy Audit Purpose & Scope, Types of Energy Audit & Methodologies, Audit Instruments, Energy Management principles, Benchmarking and Strategies, Performance assessment of Electrical utilities, Performance Assessment of Thermal Utilities, Energy Economic Analysis, Role of ESCOs.

References:

1. P. W. O'Callaghan, *Energy Management: A comprehensive guide to reducing costs by efficient energy use*, McGraw Hill, England, 1992.
2. A. K. Tyagi, *Handbook on Energy Audits and Management*, TERI, 2000.
3. IEEE Std. 739-1995, *IEEE recommended practice for energy management in industrial and commercial facilities*.
4. S. Doty and W. C. Turner, *Energy Management Handbook* (7e), Fairmont Press, USA, 2009.

EE1792: SOLAR PHOTOVOLTAICS ENERGY CONVERSION [3 0 0 3]

Solar Radiation: Spectrum, Terminologies, Measurement, Estimation; Sun-Earth Movement & Angles, Sun Tracking, PN Junction Diode & Characteristics, Solar Cell, Photovoltage, Light Generated Current, I-V equation & Characteristics: Short Circuit Current, Open Circuit Voltage, Maximum Power Point, Fill Factor, Efficiency, Losses, Equivalent Circuit, Effect of Series & Shunt Resistance, Solar Radiation, Temperature on Efficiency, Solar PV Modules: Series & Parallel connection, Hotspots, Bypass & Blocking Diodes, Power Output, Ratings, I-V & Power Curve, Effect of Solar Irradiation & Temperature, Balance of System (BOS): Batteries: Classification, Capacity, Voltage, Depth of Discharge, Life Cycle, Factors affecting Battery Performance; Charge Controllers, DC to DC Converters, DC to AC converters, Maximum Power Point Tracking (MPPT).

References:

1. C. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Application*, PHI New Delhi, 2009.
2. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modeling and Applications*, Narosa Publications New Delhi, 2013.
3. S. Deambi, *Photovoltaic System Design*, CRC Press USA, 2016.
4. F. Kreith and D. Y. Goswami, *Energy Management and Conservation Handbook* (2e), CRC Press USA, Fairmont Press, USA, 2017.
5. J. Balfour, M. Shaw and N. B. Nash, *Advanced Photovoltaic Installations*, Jones & Barlett Learning USA, 2013.