KAMLA NEHRU INSTITUTE OF TECHNOLOGY

SULTANPUR (U. P.)-228 118

(An Autonomous Institute under Dr. A. P. J. Abdul Kalam Technical University, Lucknow)

EVALUATION SCHEME & SYLLABUS

MASTER OF TECHNOLOGY (REGULAR)
Power Electronics & Drives

Choice Based Credit System
(Effective from the Session 2017-18)

KAMLA NEHRU INSTITUTE OF TECHNOLOGY, SULTANPUR

(An Autonomous Institute under Dr. A. P. J. Abdul Kalam Technical University, Lucknow)

ELECTRICAL ENGINEERING

MASTER OF TECHNOLOGY (REGULAR)
(Power Electronics & Drives)

SEMESTER – I

Sr. No.	Subject Category	Subject Code	Name of Subject	Periods		Evaluation Scheme				Subject Total	Credit
						SESSIONAL			ESE		
				L	T/P	CT	TA/LAB	Total			
1.	DC	REEC101	Fundamentals of Electric Drives	3	1/2	30	10	40	60	100	4
2.	DC	REEC102	Power Converters	3	1/2	30	10	40	60	100	4
3.	DC	REEC103	Numerical Techniques & Simulation	3	1/2	30	10	40	60	100	4
4.	DE	*	Department Elective 1	3	1/2	30	10	40	60	100	4
			Total							**400**	**16**

*** REEE101/102/103/104**

SEMESTER – II

Sr. No.	Subject Category	Subject Code	Name of Subject	Periods		Evaluation Scheme				Subject Total	Credit
						SESSIONAL			ESE		
				L	T/P	CT	TA/LAB	Total			
1.	DC	REEC201	Power Semiconductor Controlled Electric Drives	3	1/2	30	10	40	60	100	4
2.	DC	REEC202	Advanced Control Systems	3	1/2	30	10	40	60	100	4
3.	DE	**	Department Elective 2	3	1/2	30	10	40	60	100	4
4.	DE	***	Department Elective 3	3	1/2	30	10	40	60	100	4
			Total							**400**	**16**

****REEE201/202/203/204** ***** REEE301/302/303/304**

DEPARTMENT ELECTIVES

DEPARTMENT ELECTIVE 1

01 Power Electronics Applications in Power System

02 Control Techniques in power Electronics

03 Power Electronics for Renewable Energy Systems

04 Advanced Power Semiconductor Devices

DEPARTMENT ELECTIVE 2

01 Electrical Power Quality

02 Power System Security

03 Power System Dynamics

04 Economic operation of Power Systems

DEPARTMENT ELECTIVE 3

01 Advanced Microprocessor & Applications

02 Optimization Techniques

03 Artificial Neural Networks & Fuzzy Systems

04 Distributed generation and Micro grid

CODE	REEC 101	L	T	P	Credit
	FUNDAMENTALS OF ELECTRIC DRIVES	3	1	0	4

UNIT-1:

Introduction to Electric Drive:

Basic drive components, classification and operating modes of electric drive, nature and types of mechanical loads, review of speed-torque Characteristics of electric motors and load, Joint speed-torque characteristics, Plugging, dynamic and regenerative braking of dc and ac motors.

UNIT-2:

Dynamic of Electric Drives System:

Equation of motion, equivalent system of motor-load combination, stability considerations, electro-mechanical transients during starting and braking, calculation of time and energy losses, Losses in electric drive system and their minimization energy, efficient operation of drives, load equalization.

UNIT-3:

Estimation of Motor Power Rating:

Heating and cooling of electric motors, load diagrams, classes of duty, reference to Indian Standards, estimation of rating of electric motors for continuous, short time and intermittent ratings, Selection criteria of electric drive for industrial applications.

UNIT-4:

Traction Drive:

Electric traction services, duty cycle of traction drives, calculations of drive rating and energy consumption, desirable characteristics of traction drive and suitability of electric motors, control of traction drives.

UNIT-5:

Special Electric Drives:

Servo motor drive, step motor drive, linear induction motor drive, permanent magnet motor drive.

References:

1. G. K. Dubey, “Fundamentals of Electric Drive”, Narosa Publishing House, 1995.
2. S. K. Pillai, “A first course on Electric Drive”, New Age International Publishers, 1981
3. M. Chilkin, “Electric Drive”, Mir Publications.
4. N. K. De and P. K. Sen, “Electric Drives”, Prentice Hall of India, 1999.
5. Vedam Subramanian, “Electric Drive: Concepts and Applications”, Tata McGraw Hill, 1994.

CODE	REEC 102	L	T	P	Credit
	POWER CONVERTERS	3	1	0	4

UNIT-1:

DC-DC Switched Mode Converters:

Review of Buck Converter, Boost Converter, Buck-Boost, Duty cycle derivation, Different conduction modes (CCM & DCM), Voltage and Current waveforms, Calculation of output voltage ripple.

UNIT-2:

Voltage Source Converters:

3-phase full wave bridge converter, operation and harmonics, Transformer connection for 12 pulse operation, 24 and 48 pulse operation. Operation of 12-pulse converter. 3-level voltage source converter. PWM converter. Generalized technique of harmonic elimination and voltage control. Advanced modulation techniques (SPWM, space vector modulation, 3^{rd} harmonic PWM) Comparison of PWM techniques, Converter rating.

UNIT-3:

Self and Line Commutated Current Source Converter:

Basic concepts and principle of operation of CSC, converters with self commutating devices. Comparison with voltage source converter

UNIT-4:

Resonant Converters:

Switch-mode inductive current switching, Zero Voltage & Zero Current switching , Resonant switch converters, Basic resonant circuit concepts, Resonant switch converters, ZCS and ZVS resonant switch converters , Comparison of ZCS and ZVS topologies. Load resonant converters, resonant switch converters, resonant dc-link Converters, high-frequency-link integral half cycle converters.

UNIT-5:

Multilevel Converters:

Multilevel concept, Types of multilevel converters, diode clamped multilevel converters, flying-capacitors multilevel converters, cascaded multilevel converters, Vienna Converter, applications switching device currents, d. c. link capacitor voltage balancing, features of multilevel converters, comparison of multilevel converters.

References:

1. K. Kit Sum, "Switch-Mode Power Conversion: Basic theory and design", Marcel Decker.
2. G. Chryssis, "High Frequency Switching Power supplies: Theory and Design", Mc Graw Hill.
3. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications", Prentice Hall of India, 1996.

4. N. Mohan, T. M. Undeland and W. P. Robbins, "Power Converters, Applications and Design", John Wiley & Sons, 1995.
5. G. K. Dubey et al, "Thyristorized Power Controllers", Wiley Eastern, 1987.
6. B. R. Pelly, "Thyristor Phase Controlled Converters and Cyclo-converters", Wiley Intersicence, 1971.
7. M. D. Singh and K. B. Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
8. V. Subrahmanyam, "Power Electronics", New Age International Publishers, 1997.
9. D. Grahame Holmes, Thomas A. Lipo, T. A. Lipo "Pulse width modulation for power converters: principles and practice", Wiley-IEEE press, 2003.

CODE	REEC 103	L	T	P	Credit
	NUMERICAL TECHNIQUES & SIMULATION	3	1	0	4

UNIT-1:

Calculus of Finite Differences & Interpolation:

$\Delta, \nabla, E\ E^{-1}$ and their relations, Interpolation with equal intervals-Newton-Gregory formula for forward and backward interpolations, Interpolation with unequal intervals-Lagrange's interpolation formula, inverse interpolation.

UNIT-2:

Curve Fitting & Numerical Analysis:

Method of least square, Curve fitting procedures for linear, power and exponential curves, Numerical integration-trapezoidal, Simpson's one-third & three-eighth rule, Numerical computations & solutions-Gauss-Seidal, Newton-Raphson & Runge-Kutta methods.

UNIT-3:

Programming Basics:

General overview & understanding of MATLAB and its interface – command window, workspace, data types, dimensions, case sensitivity, variables and assignments, vector and matrices, arithmetic / relational / logical operators; Basic matrix operations, Concatenation of Matrices, Eigen values and eigen vectors, Polynomial roots, Differentiation and integration, Complex arithmetic, Solution of linear equations, Solution of ordinary differential equations (ODE), Plotting of 2D and 3D curves, Subplot, Figure Editor, Data analysis and statistics.

UNIT-4:

Programming Applications:

Flow control structures (if-else, for, while, switch and case, continue, break, return), Built-in and user-defined functions, Programming in M-files, Script & Function files, MATLAB programming applications in-interpolation, numerical computations & solutions, fitting a polynomial curve, signal analysis, electrical circuits analysis (RC, RL, RLC type) and frequency responses analysis of transfer functions.

UNIT-5

Modeling & Simulation of Electrical Systems:

Simulink-Simulink model editor, Simulink blocks library, concepts of blocksets, block diagram construction, subsystem, simulation parameters & solvers, S-function, passing parameters to S-function, running a simulation; Sim Power Systems blockset, Simulink based modeling & simulation of electrical circuits, Linear state-space modeling & simulation, MATLAB toolboxes-symbolic math toolbox, control system toolbox, signal processing toolbox and fuzzy logic toolbox.

References:

1. H.C. Saxena, "Finite Differences and Numerical Analysis", S. Chand & Co., New Delhi, 1993.
2. S. C. Gupta & V. K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, New Delhi
3. Rudra Pratap, "Getting Started with MATLAB 7".
4. The MathWorks Inc., "MATLAB: The Language of Technical Computing".
5. The MathWorks Inc, "SIMULINK: Dynamic System Simulation".
6. The MathWorks Inc., "Sim Power Systems: User's Guide".
7. B. R. Hunt, R. L. Lipsman & J. M. Rosenberg, "A Guide to MATLAB", Cambridge University Press, 2003.
8. O. Beucher and M. Weeks, "Introduction to MATLAB & SIMULINK-A Project Approach", Infinity Science Press LLC, Hingham, MA, Third Edition.

CODE	REEC 201	L	T	P	Credit
	POWER SEMICONDUCTOR CONTROLLED ELECTRIC DRIVES	3	1	0	4

UNIT-1:

Introduction:

Solid state controlled electric drives-concept, elements and salient features, Power converter motor system, Closed-loop control of electric drives, Sensing of speed and current, Performance parameters.

UNIT-2:

Control of D.C. Drives:

Control of DC separately and series excited motor drives using controlled converters (single phase and three-phase) and choppers, Static Ward-Leonard control scheme, Solid-state electric braking schemes, Current and speed control loops for closed-loop control of solid state DC drives; (P, PI and PID) controllers-response comparison, Simulation of converter and chopper fed DC drive.

UNIT-3:

Control of A.C. Motor Drives:

Operation of induction and synchronous motor drives from voltage source and current source inverters, Static rotor resistance control, Injection of voltage in the rotor circuit, Slip power recovery-static Kramer's and Scherbius's drives, Pump drives using AC line controllers, Self controlled synchronous motor derives, Brushless DC motor drive, Switched reluctance motor drive.

UNIT-4:

Scalar and Field Oriented Control:

Constant and variable frequency operation, Constant V/Hz operation, Field-oriented control of induction and synchronous machines-theory, DC drive analogy, direct and indirect methods, flux vector estimation, Direct torque control of induction and synchronous machines-torque expression with stator and rotor fluxes, DTC control strategy.

UNIT-5:

Microprocessor Control of Electric Drive:

Function of microprocessor in electric drive control, Salient features of microprocessor control, Microprocessor based control scheme for DC, induction and synchronous motor drives, Applications.

References:

1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall International, 1989.
2. J. M. D. Murphy & I.G. Turnbull, "Power Electronic Control of A.C. Motors", Pergamon Press, 1988.
3. S. B. Dewan & G. R. Slemon & A Straughen, "Power Semiconductor Drives". Wiley Interscience, 1984.
4. V. Subrahmanyam, "Thyristor Control of Electric Motors", Tata Mc Graw Hill.
5. B. K. Bose, "Power Electronics and AC Drives", Prentice Hall International, 1986.
6. P. C. Sen, "Thyristor DC Drives", Wiley Interscience, 1987.
7. R. Krishan, "Electric Motor Drives Modeling, Analysis and Control", Prentice Hall International, 2002.

CODE	REEC 202	L	T	P	Credit
	ADVANCED CONTROL SYSTEMS	3	1	0	4

UNIT-1:

State Space Analysis of Continuous-time LTI System:

Review of state space representation of continuous linear time invariant system, Conversion of state variable models to transfer functions and vice-versa, Transformation of state variables, Solution of state equations, Similarity transformation.

UNIT-2:

Controllability and Observability:

State and output controllability and observability, Kalman's and Gilbert's Tests for controllability and Observability.

UNIT-3:

Analysis of Discrete-time System:

Discrete time signals and systems, z-transformation, modeling of sample-hold circuit, pulse transfer function, solution of difference equation by z-transform method, stability analysis in z-plane.

UNIT-4:

Analysis of Nonlinear System:

Common physical nonlinearities, singular points, phase plane analysis, limit cycles, describing function method and stability analysis, jump resonance, Linearization of nonlinear systems. Lyapunov stability, Methods for generating Lyapunov function, Statement of Lure problem, Circle criterion, Popov's criterion.

UNIT-5:

Optimal and Adaptive Control:

Basic concepts of optimal control, Adaptive control, intelligent control and robust control systems.

References:

1. K. Ogata, "Modern Control Engineering", John Wiley & Sons, 2001.
2. Norman S. Nise, "Control System Engineering", John Wiley & Sons, 2001.
3. Kuo B. C., "Digital Control Systems", Saunders College Publishing, 1992.
4. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill, 1997.
5. I. J. Nagrath & M. Gopal, "Modern Control Engineering", New Age International, 2005.
6. S. M. Tripathi, "Modern Control Systems: An Introduction", Jones & Bartellet Publishers, USA, 2009.
7. M. Gopal, "Modern Control System Theory", Wiley Eastern, 1993.
8. K. Ogata, "Discrete Time Control System", Prentice Hall International, 1987.

DEPARTMENT ELECTIVE -I

CODE	REEE 101	L	T	P	Credit
	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS	3	1	0	4

UNIT-1:

Introduction:

Concept of reactive power control in electrical power transmission lines, Uncompensated transmission line, Series & shunt compensation, Concept and merits of on line tap changing transformer (OLTC), Phase modifier circuit, Capacitor banks, Inductor banks etc.

UNIT-2:

Static VAR Compensator (SVC) and its Applications:

Voltage control by SVC, Advantages of slope in dynamic characteristics, Influence of SVC on system voltage, Design of SVC voltage regulator, Modeling of SVC for power flow and transient stability, Applications: Enhancement of transient stability, Steady-state power transfer, Enhancement of power system damping, Prevention of voltage instability.

UNIT-3:

Thyristor Controlled Series Capacitor (TCSC) and its Applications:

Operation of TCSC, Different modes of operation, Modeling of TCSC, Variable reactance model, modeling for power flow and stability studies, Applications: Improvement of the system stability limit, Enhancement of system damping, SSR Mitigation.

UNIT-4:

Voltage Source Converter based FACTS Controllers:

Static Synchronous Compensator (STATCOM), Principle of operation, V-I Characteristics, Applications: Steady state power transfer, Enhancement of transient stability, Prevention of voltage instability, SSSC, Operation of SSSC, Control of power flow, Modeling of SSSC in load flow and transient stability studies, Applications: SSR Mitigation, UPFC and IPFC.

UNIT-5:

Placement & Co-ordination of FACTS Controllers:

Controller interactions, SVC, SVC interaction, Co-ordination of multiple controllers using linear control techniques, Control coordination using AI techniques (Fuzzy / Neuro / Genetic Algorithm).

References:

1. N.G. Hingorani and I. Gyugyi, "Understanding FACTS", IEEE Press, 1999
2. Y. H. Songh and A. T. Johns. ed., "Flexible AC Transmission Systems (FACTS)", IEEE 1999.
3. R. Mohan Mathur, Rajiv K. Varma, "Thyristor-Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
4. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008

5. V. K. Sood, “HVDC and FACTS controllers-Applications of Static Converters in Power System”, April 2004 , Kluwer Academic Publishers

CODE	REEE 102	L	T	P	Credit
	ADVANCE CONTROL IN POWER ELECTRONICS	3	1	0	4

UNIT-1:
State space modeling and simulation of linear system, discrete time models, conventional controllers using small signal models.

UNIT-2:
Variable structure and sliding mode control, hysteresis controllers, output and state feedback switching controllers.

UNIT-3:
Linear Quadratic Controller (LQR), Deadbeat controller, pole shift controller.

UNIT-4:
Structure and control of Power converters: single-phase H-bridge and three-phase inverter, multilevel inverters, PWM for inverters;

UNIT-5:
Introduction of fuzzy and neural network control of power converters.

References:

1. Arindum Ghosh & Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers
2. M. Gopal, “Digital Control and State variable Methods”, Tata Mc Graw Hill
3. Ajit K. Madal, “Introduction to Control Engineering: Modeling, Analysis and Design”, New Age International.
4. S. Rajasekaran & G.A.Vjayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications”, Prentice Hall of India.
5. Donald E. Kiv, “Optimal Control Theory: An Introduction”, Prentice Hall
6. B. C. Kuo, “Digital Control Systems”, Sounders College Publishing
7. C. H. Houpisand G. B. Lamont, “Digital Control Systems: Theory, Hardware, Software”, Mc Graw Hill.

CODE	REEE 103	L	T	P	Credit
	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	3	1	0	4

UNIT-1:

Introduction to Renewable Energy Sources:

Introduction, importance, classification and qualitative study of different renewable energy resources: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and Hybrid renewable energy systems.

UNIT-2:

Renewable Energy Converters:

Three-phase AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters, matrix converters, Principle of operation: line commutated converters (inversion-mode), Boost and buck-boost converters

Electrical Machines:

Review of reference theory fundamentals, Principle of operation and analysis: SCIG, PMSG, and DFIG.

UNIT-3:

Wind Power Conversion Systems:

Wind power and its sources, wind characteristics, wind power generator, performance and limitations, Stand-alone operation of fixed and variable speed wind energy conversion systems, Grid integrated PMSG and SCIG Based WECSs, Machine side & Grid side controllers, Grid connection Issues related to Wind Systems.

UNIT-4:

Solar Power Conversion Systems:

Theory of solar cells, solar materials, solar cell power plant, limitations, Block diagram of solar photo-voltaic system, selection of inverter, battery sizing, array sizing, Grid Integrated solar system, Grid connection Issues related to solar systems.

UNIT-5:

Hybrid Renewable Energy Systems:

Need for Hybrid Systems, Range and types of Hybrid systems, Wind-Diesel Hybrid System, Wind-Photovoltaic Hybrid Systems, Photovoltaic-Diesel Hybrid System, Case studies of Wind-PV Maximum Power Point Tracking (MPPT), Grid connection Issues related to hybrid systems.

References:

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford Press.
2. Rai. G. D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G. D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall, 1995.
5. B. H. Khan, Non-conventional Energy sources, Tata Mc Graw-hill, New Delhi.
6. L. L. Freris “Wind Energy conversion Systems”, Prentice Hall, 1990

7. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.
8. E. W. Golding “The generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge, 1976.
9. S. Heir “Grid Integration of WECS”, Wiley 1998.

CODE	REEE 104	L	T	P	Credit
	ADVANCED POWER SEMICONDUCTOR DEVICES	3	1	0	4

UNIT-1:

Introduction:

General overview of power semiconductor devices and their desirable characteristics comparison of power semiconductor devices.

Power Diodes:

General purpose diode, fast recovery diode, schottky diode, diode snubbers.

UNIT-2:

Power Bipolar Junction Transistors:

Physical structure and device operation, static V-I and switching characteristics, secondary breakdown and safe operating area, snubber circuits, base drive control.

Power MOSFETS:

Physical structure and device operation, static V-I and switching characteristics, operating limitations and safe operating area, gate drive and snubber circuits

UNIT-3:

Thyristors:

Physical structure and device operation, two transistor analogy, static V-I and switching characteristics, gate characteristics, firing circuits, snubber circuits series and parallel operation.

TRIACS:

Physical structure and device operation, static V-I characteristics and applications

UNIT-4:

GTO (Gate Turn Off) Thyristors:

Physical structure and device operation, Static V-I and switching characteristics, drive and snubber circuits.

Insulated Gated Bipolar Transistors (IGBT):

Physical structure and device operation, static V-I and switching characteristics, safe operating area, drive and snubber, circuit.

UNIT-5:

Special Power Devices:

Physical structure, device operation and static V-I characteristics of Reverse conducting thyristor, field controlled thyristor, MOS controlled thyristor.

References:

1. B. Jayant Baliga, "Modern Power Devices", John Wiley & Sons, 1987.
2. N. Mohan, T. M. Undeland and W.P. Robbins, "Power Electronics Converters, Applications and Design", Johan Wiley & Sons, 1995.
3. M. H. Rashid, "Power Electronics: Circuit, Devices and Applications", Prentice Hall of India, 1996.
4. Dubey G. K. et al, "Thyristorised Power Controllers", Wiley Eastern Limited 1987.
5. M. D. Singh and K. B. Khanchandani, "Power Electroncs", Tata McGraw Hill, 2001.
6. John G. K. Kassakian, Martin F. Schlecht and G. C. Verghese, "Principles of Power Electronics", Addison-Wesley Publishing Co., 1991.

DEPARTMENT ELECTIVE 2

CODE	REEE 201	L	T	P	Credit
	ELECTRICAL POWER QUALITY	3	1	0	4

UNIT-1:

Introduction to Power Quality:

Terms and definitions of transients, Long duration voltage variations-overvoltage, undervoltage and sustained interruptions, Short duration voltage variations-Interruption, Sag, Swell, Voltage and phase angle imbalances, Waveform distortion, Voltage fluctuation, Power frequency variations, Electrical noise, Harmonics, Frequency deviation monitoring.

UNIT-2:

Voltage Sag & Electrical Transients:

Sources of voltage sag-motor starting, arc furnace, fault clearing etc; Estimating voltage sag performance and principle of its protection; Solutions at end user level-isolation transformer, voltage regulator, static UPS, rotary UPS, emergency & standby power systems, applications of power conditioners, active series compensator; Sources of transient overvoltage-atmospheric and switching transients, motor starting transients, pf correction capacitor switching transients, UPS switching transients, neutral voltage swing etc; Devices for over voltage protection.

UNIT-3:

Harmonics:

Causes of harmonics; Current and voltage harmonics-measurement of harmonics; Effects of harmonics on-transformers, AC motors, capacitor banks, cables, and protection devices, energy metering, communication lines etc., Harmonic mitigation techniques.

UNIT-4:

Monitoring and Measurement of Power Quality:

Power quality measurement devices-harmonic analyzer, transient disturbance analyzer, wiring and grounding tester, flicker meter, oscilloscope, multimeter etc. Minimization of Disturbances at Customer Site. Power quality related standards, Standard test waveforms, Power distribution system design, Measures to minimize voltage disturbances.

UNIT-5:

Introduction to Custom Power Devices:

Network reconfiguration devices; Load compensation and voltage regulation using DSTATCOM; Protecting sensitive loads using DVR; Unified power quality conditioner (UPQC).

References:

1. G. W. Heydt, "Electric Power Quality", Stars in a Circle Publications, 1991.
2. R. C. Dugan, M. F. Megranaghan and H. W. Beaty, "Electric Power System Quality", Mc-Graw Hill International.

3. G. J. Parter and J. A.V. Sciver, "Power Quality Salutations: Case Study for Troubleshooters", Fairmont Press.
4. Arindum Ghosh & Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers.
5. C. Sankaran, "Power Quality", CRC Press.

CODE	REEE 202	L	T	P	Credit
	POWER SYSTEM SECURITY	3	1	0	4

UNIT-1:
Introduction:
Basic concepts and definitions of Rotor angle stability, Voltage stability or voltage collapse and Mid-term and long-term stability, Classification of stability.

UNIT-2:
Basic Concepts:
Power system-security-observability and reliability, factors affecting power system security, decomposition and multilevel approach, system monitoring, security assessment, static and dynamic – online and offline, security enhancement.

UNIT-3:
Power System State Estimation: DC and AC network, orthogonal decomposition algorithm, detection identification of bad measurements, network observability and pseudo measurements, application of power system state estimation, introduction to supervisory control and data acquisition.

UNIT-4:
Power System Security Assessment: contingency analysis, network sensitivity factors, contingency selection, performance indices, security constrained optimization, SCOPF, basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non-linear programming (NLP) and linear programming (LP) methods.

UNIT-5:
Security in Deregulated Environment: Need and conditions for deregulation, electricity sector structure model, power wheeling transactions, congestion management methods, available transfer capability (ATC), system security in deregulation.

References:

1. Wood and Wollenberg, "Power generation, operation and control", John Wiley & Sons, 2000.
2. K. Bhattacharya, M. H. J Bollen and J. E. Daaider, "Operation of restructured power system", Kluwer Power Electronics and Power System series (2001)

3. N. S. Rau, "Optimization Principles: Practical Applications to the operation and Markets of the Electric Power Industry".
4. Sally Hunt, "Making competition work in Electricity", John Wiley, 2002

CODE	REEE 203	L	T	P	Credit
	POWER SYSTEM DYNAMICS	3	1	0	4

UNIT-1:

Synchronous Machine Modelling:

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, MMF waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, self and mutual inductances of stator and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: Lad-reciprocal per unit system and that from power-invariant form of Park's transformation; Equivalent circuit and steady state analysis, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : by Neglecting of stator $p\Psi$ terms and speed variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT-2:

Modelling of Excitation and Speed Governing Systems:

Excitation System Types, Control and protective functions; IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System

Modelling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

UNIT-3:

Small-signal Stability Analysis without Controllers:

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-space representation, stability of dynamic system, Linearization. Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability.

UNIT-4:

Small-signal Stability Analysis with Controllers:

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System **Stabiliser:** Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example.

UNIT-5:

Enhancement of Small Signal Stability:

Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers. Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta – P-Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain-Phase lead compensation – Stabilizing signal washout stabilizer gain – Stabilizer limits.

References:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Trans., Vol. PAS-92, pp 1904-1915, November/December, on Turbine-Governor Model, 1973.
3. P. M. Anderson and A. A. Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.
4. R. Ramanujam, "Power System Dynamics, Analysis and Simulation", PHI Learning, New Delhi, January 2010.

CODE	REEE 204	L	T	P	Credit
	ECONOMIC OPERATION OF POWER SYSTEM	3	1	0	4

UNIT-1:

Power system restructuring:

Introduction, Market Structure and operation:- Objective of market operation, Electricity market models, Power market types, Market power, Key components in market operation. Demand and supply, Demand analysis - theory of demand, Elasticity of demand, Demand forecasting types-techniques of forecasting.

UNIT-2:

Economics of Power Generation:

Introduction, cost of electrical energy, expression for cost of electrical energy, depreciation, power plant cost analysis, economics in plant selection, selection of types of generation and types of equipments, factors effecting economic generations and distributions, generating cost.

UNIT-3:

Economical Operations of Thermal Power Plants:

Generator operating cost, input and output curves, heat rate and incremental rate curves of generating units, system constraints, economic dispatch problem, economic dispatch using Newton Raphson method, classical method, Calculation of loss coefficient using Ybus, using Sensitivity Factors: Generation Shift Distribution (GSD) factors, Generalised Generation shift Distribution (GGSD) Factors. Effects of transmission losses, transmission loss coefficients, formula, function of generation and loads, economic dispatch using exact loss formula which is function of real and reactive power, evaluation of incremental transmission loss, economic dispatch based on penalty factors.

UNIT-4:

Economical Operations of Hydrothermal Power Plants:

Classification of hydro plants, long-range and short-range problem. Hydro Plant performance Model, Glimn- Kirchmayer Model, Hamilton-Lamonts Model, thermal and hydro model for short range fixed head hydrothermal scheduling, equality and inequality constraints, transmission losses, advantages of combined operation, base load, peak load operation requirement, Newton Raphson method for short range fixed head hydrothermal scheduling, reservoir dynamics, equality and inequality constraints, idea of multi-objective generation scheduling.

UNIT-5:

Interconnected System:

Merits and demerits, parallel operation of alternators, synchronizing current, power & toque, effect of change of excitation, driving torque & speed of one of the alternators, load sharing and power limit of interconnected stations, voltage, frequency & load control of interconnected stations.

References:

1. Maket Operations in Electric Power Systems (IEEE)- Mohammad Shahidehpour, Hatim Yamin, Zuyi Li ,A John Wiley & Sons, Inc., Publications
2. Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.
3. Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002.
4. Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H. J. Boolen, Kluwer Academic Pub., 2001.
5. Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001

6. W. H. J. R. Dunn, M. A. Rossi, B. Avaramovic: Impact of market restructuring on power systems operation, IEEE computer Applications on Power Engineering, vol. 8, January 1995, pp 42–47.
7. M. A. Olson, S. J. Rassenti, V. L. Smith: Market design and motivated human trading behaviors in electricity markets, in Proceedings of 34th Hawaii International Conference Systems Science, Hawaii, January 5–8, 1999
8. X. Guan, P. B. Luh: Integrated resource scheduling and bidding in the deregulated electric power market: New challenges, Special Issue J. Discrete Event Dynamical Systems, Vol. 9, No. 4, 1999, pp 331–350.
9. Turner, Wayne. C., Energy Management Hand Book.,2nd Edition
10. Industrial Economics-an introductory text book. R R Barathwal- Professor IIT Kanpur
11. Micro Economics-Theory and Application by Aninydya Senpplied economics for Engineers and Managers by S. K. Jain – Vikas Publishing House.
12. Series on Electrical Power capacitors Reactive power Management, D. M. Tagare, Madhav Electricals, Pune, Tata McGraw Hill Publishing Company Ltd
13. K. Kirchmayr, “Economic Control of interconnected systems”, J. Wiley Publications.
14. Robert H Miller & James H. Malinowski, “Power System Operation”, TMH Publications

DEPARTMENT ELECTIVE 3

CODE	REEE 301	L	T	P	Credit
	ADVANCED MICROPROCESSORS & APPLICATIONS	3	1	0	4

UNIT-1:

Introduction:

Review of basic microprocessor, Architecture and instruction set of a typical 8 bit microprocessor, Concepts of micro controller and micro computer, Micro controllers (8051/8751) based design, Applications of micro computer in on line real time control.

UNIT-2:

Advanced Microprocessor:

Overview of 16 bit and 32 bit microprocessors, Arithmetic and I/O coprocessors, Architecture, Register details, Operation, Addressing modes and instruction set of a 16 bit 8086 microprocessor, Assembly language programming, Introduction to multiprocessing, Multi-user, Multitasking operating system concepts, Pentium I, II, III and IV processors, Motorola 68000 processor.

Analog Input & Output:

Microprocessor compatible ADC and DAC chips, Interfacing of ADC and DAC with microprocessor, User of sample and hold circuit and multiplexer with ADC

UNIT-3:

Input-Output Interfacing:

Parallel and series I/O, programmed I/O, Interrupt driven I/O, single and multi interrupt levels, Use of software polling and interrupt controlling for multiplying interrupt levels, Programmable interrupt controller, DMA controller, Programmable timer/counter, Programmable communication and peripheral interface, Synchronous and asynchronous data transfer, Standard serial interfaces like Rs. 232.

Programmable Support Chips:

Functional schematic, operating modes, Programming and interfacing of 8255, 8251, 8259 and 8253 with microprocessor

UNIT-4:

Control of Power Converters:

Control strategies and microprocessor based control schemes for line converters, AC voltage controllers, Cyclo-converters, Choppers and Bridge inverters.

UNIT-5:

Sensing and Processing of Feedback Signals:

Sensing of position, speed, current, torque for feedback purposes and signal conditioning, Synchronizing signals, Quantization, Digitalization, Filtering and implementation, Microprocessor in electric drive control, Selection criteria

References:

1. R. S. Gaonker, "Microprocessor Architecture, Programming and Application", Wiley Eastern Limited.
2. M. D. Singh and K. B. Khanchandani, "Power Electronics", Tata Mc Graw Hill, 2001.
3. B. K. Bose, "Power Electronics and Variable Frequency Drive", Standard Publishers Distributions, 2000.
4. D. V. Hall, "Microprocessors and Interfacing Programming and Software," Mc Graw Hill.

CODE	REEE 302	L	T	P	Credit
	OPTIMIZATION TECHNIQUES	3	1	0	4

UNIT-1:

Fundamentals of Optimization:

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming).

UNIT-2:

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 based Economic Dispatch solution, Fuzzy Economic Dispatch including losses, Tabu search algorithm for unit commitment problem, GA for unit commitment, GA based Optimal power flow, GA based state estimation.

UNIT-3:

Particle Swarm Optimization:

Fundamental principle, Velocity Updating-Advanced operators, Parameter selection, Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO), Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues, PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

UNIT-4:

Advanced Optimization Methods:

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT-5:

Multi Objective Optimization:

Concept of Pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO)-Multiobjective OPF problem.

References:

1. D. P. Kothari and J. S. Dhillon, "Power System Optimization", 2nd Edition, PHI learning private limited, 2010.
2. Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", John Wiley and Sons, 2008.
3. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice hall of India first edition, 1988.
4. Carlos A. Coello Coello, Gary B. Lamont, David A. Van Veldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2nd Edition, Springer, 2007.
5. Soliman Abdel Hady, Abdel Aal Hassan Mantawy, "Modern optimization techniques with applications in Electric Power Systems", Springer, 2012.
6. Jizhong Zhu, "Optimization of power system operation", John Wiley and sons Inc publication, 2009.
7. Kwang Y. Lee, Mohammed A. El Sharkawi, "Modern heuristic optimization techniques", John Wiley and Sons, 2008.

CODE	REEE 303	L	T	P	Credit
	ARTIFICIAL NEURAL NETWORKS AND FUZZY SYSTEM	3	1	0	4

[A] Artificial Neural Networks

UNIT-1:

Basics of Neural Networks:

Introduction and Architecture, Simple neuron, Nerve structure and synapse, Concept of multilayer nets, Auto-associative and hetero-associative nets, Artificial neural networks, Neural network tools (NNTs), Neuron signal functions, Neuron models, Neuron activation, Artificial neural network (ANN) vs. Traditional computers.

UNIT-2:

Learning Techniques:

Learning in neural nets, Unsupervised and supervised learning, Hebbian learning, Competitive learning, Perception learning and convergence theorem, Single-layer & Multilayer perceptron models, Back-propagation algorithm.

UNIT -3

Applications of Neural Networks:

Applications in load flow study, load forecasting, detection of faults in distribution system, steady-state stability and electric drives control; Neural network simulator.

[B] Fuzzy System

UNIT-4:

Basics of Fuzzy System:

Fuzzy sets and systems, Basic concepts of fuzzy logic , Fuzzy sets and crisp sets, Properties of fuzzy sets, Fuzzy set theory and operations, Fuzzy and crisp relations, Fuzzy to crisp conversions, Fuzzy entropy theorem.

UNIT- 5:

Fuzzy Membership, Rules and Applications:

Fuzzy numbers and Fuzzy vectors, Membership functions, Basic principle of interface in fuzzy logic, Fuzzy IF-THEN rules, Fuzzy algorithms, Approximate reasoning, Interference in fuzzy logic, Fuzzy inference engines, Fuzzy implications, Fuzzification, Defuzzification. Fuzzy control system and its elements, Fuzzy logic controller, Neuro-fuzzy control, Fuzzy control in industrial applications.

References:

1. Bart Kosko, “Neural Networks & Fuzzy Systems”, Prentice Hall International.
2. George J. Klin & Tina A. Polger, “Fuzzy Sets, Uncertainty and information”, Press Inc.
3. Timothy. J. Ross,”Fuzzy Logic with Engineering Applicatioons”.
4. Russel C. Ebehart & Roy W. Dobbins, “Neural Network PC tools”, Academic Press Inc.
5. Kumar Satish, “Neural Networks” Tata Mc Graw Hill.
6. S. Rajsekaran & G. A. Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications”, Prentice Hall of India.
7. N. K. Bose & P. Liang, “Neural Network Fundamentals with Graphs Algorithms and Applications”, Tata Mc Graw Hill.
8. Simon Haykin, “Neural Networks”, Prentice Hall of India.
9. S. Rajasekaran & G. A. Vijay Lalakshim Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms, Synthesis and Applications”, Prentice hall of India
10. N. P. Padhy, “Artificial intelligence and Intelligent Systems”, Oxford University Press.
11. S. N. Sivanandam, S. Sumathi, S. N. Deepa, “Introduction to Neural Networks using MATLAB 6.0”, Tata Mc Graw Hill.

CODE	REEE 304	L	T	P	Credit
	DISTRIBUTED GENERATION AND MICRO-GRID	3	1	0	4

UNIT-1:

Introduction:

Conventional power generation: advantages and disadvantages, Energy crisis, review of Non-conventional energy (NCE).

UNIT-2:

Distributed Generations (DG):

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT-3:

Impact of Grid Integration:

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT-4:
Microgrids:
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT-5:
Power Quality Issues in Microgrids:
Power quality issues in microgrids-Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

References:

1. Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
2. Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi, 2009.
4. J. F. Manwell, "Wind Energy Explained, theory design and applications," J. G. McGowan Wiley publication, 2002.
5. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, 2005.

KAMLA NEHRU INSTITUTE OF TECHNOLOGY

SULTANPUR (U. P.)-228 118

(An Autonomous Institute under Dr. A. P. J. Abdul Kalam Technical University, Lucknow)

EVALUATION SCHEME & SYLLABUS

MASTER OF TECHNOLOGY (PART-TIME)

Power System

Choice Based Credit System

(Effective from the Session 2017-18)

KAMLA NEHRU INSTITUTE OF TECHNOLOGY, SULTANPUR

(An Autonomous Institute under Dr. A. P. J. Abdul Kalam Technical University, Lucknow)

ELECTRICAL ENGINEERING

MASTER OF TECHNOLOGY (Part-Time)
(Power System)

SEMESTER –I

Sr. No.	Subject Category	Subject Code	Name of Subject	Periods		Evaluation Scheme				Subject Total	Credit
						SESSIONAL			ESE		
				L	T/P	CT	TA/LAB	Total			
1.	DC	PEEC 101	Power System Operation & Control	3	1/2	30	10	40	60	100	4
2.	DC	PEEC 102	Numerical Techniques & Simulation	3	1/2	30	10	40	60	100	4
3.	DC	PEEC 103	Power Converters	3	1/2	30	10	40	60	100	4
			Total							**300**	**12**

SEMESTER –II

Sr. No.	Subject Category	Subject Code	Name of Subject	Periods		Evaluation Scheme				Subject Total	Credit
						SESSIONAL			ESE		
				L	T/P	CT	TA/LAB	Total			
1.	DC	PEEC 201	Advanced Protective Relaying	3	1/2	30	10	40	60	100	4
2.	DC	PEEC 202	Computer Aided Power System Analysis	3	1/2	30	10	40	60	100	4
3.	DE	*	Department Elective 1	3	½	30	10	40	60	100	4
			Total							**300**	**12**

***PEEE 101/102/103/104/105**

LIST OF DEPARTMENT ELECTIVES

DEPARTMENT ELECTIVE 1

01 Advance Control System

02 Power System Planning and Reliability

03 Power Electronics Applications in Power System

04 Distributed generation and Micro grid

05 Power Electronics for Renewable Energy Systems

CODE	PEEC 101	L	T	P	Credit
	POWER SYSTEM OPERATION AND CONTROL	3	1	0	4

UNIT-1:

Introduction:

Large scale power systems-their interconnections and operation; load dispatch centre and control centre, introduction to centralized and decentralized controls; various operational stages of power system; power system security.

UNIT-2:

Economic Operation:

Problem of unit commitment, system constraints, incremental fuel cost, economic load scheduling with and without transmission losses, penalty factor, loss coefficient, incremental transmission loss; optimal power flow problem; optimal operation of hydro-thermal system.

UNIT-3:

Load Frequency Control:

Concept of load frequency control, speed governing systems and its representation, automatic generation control modeling of single area and multi-area systems, tie line control, supervisory control; automatic generation control including excitation system, optimum load frequency control.

UNIT-4:

Voltage and Reactive Power Control:

Concept of voltage control, methods of voltage control reactive power injection, control by tap changing transformer series compensation, static VAR compensation, Excitation system stabilizer: Rate feedback controller, PID controller.

UNIT-5:

State Estimation:

State estimation detection and identification linear and nonlinear models.

Flexible AC Transmission System:

Concept and objectives, basic FACTS controllers TCR, FC-TSC, SVC, STATCOM. TCSC, SSSC, PAR and UPFC

References:

1. O. I. Elgerd, "Electric Energy System Theory", Mc Graw Hill, 1971.
2. Leon K. Kirchmayer, "Economic Operation of Power Systems", Wiley Eastern Ltd.
3. A. Chakrabarti, D. P. Kothari and A. K. Mukhopadhyay, "Performance, Operation and Control of EHV Power Transmission Systems", Wheeler Publishing Co.

CODE	PEEC 102	L	T	P	Credit
	NUMERICAL TECHNIQUES & SIMULATION	**3**	**1**	**0**	**4**

UNIT-1:

Calculus of Finite Differences & Interpolation:

$\Delta, \nabla, E\ E^{-1}$ and their relations, Interpolation with equal intervals-Newton-Gregory formula for forward and backward interpolations, Interpolation with unequal intervals-Lagrange's interpolation formula, inverse interpolation.

UNIT-2:

Curve Fitting & Numerical Analysis:

Method of least square, Curve fitting procedures for linear, power and exponential curves, Numerical integration-trapezoidal, Simpson's one-third & three-eighth rule, Numerical computations & solutions-Gauss-Seidal, Newton-Raphson & Runge-Kutta methods.

UNIT-3:

Programming Basics:

General overview & understanding of MATLAB and its interface-command window, workspace, data types, dimensions, case sensitivity, variables and assignments, vector and matrices, arithmetic / relational / logical operators; Basic matrix operations, Concatenation of Matrices, Eigen values and eigen vectors, Polynomial roots, Differentiation and integration, Complex arithmetic, Solution of linear equations, Solution of ordinary differential equations (ODE), Plotting of 2D and 3D curves, Subplot, Figure Editor, Data analysis and statistics.

UNIT – 4:

Programming Applications:

Flow control structures (if-else, for, while, switch and case, continue, break, return), Built-in and user-defined functions, Programming in M-files, Script & Function files, MATLAB programming applications in-interpolation, numerical computations & solutions, fitting a polynomial curve, signal analysis, electrical circuits analysis (RC, RL, RLC type) and frequency responses analysis of transfer functions.

UNIT-5:

Modeling & Simulation of Electrical Systems:

Simulink-Simulink model editor, Simulink blocks library, concepts of blocksets, block diagram construction, subsystem, simulation parameters & solvers, S-function, passing parameters to S-function, running a simulation; Sim Power Systems blockset, Simulink based modeling & simulation of electrical circuits, Linear state-space modeling & simulation, MATLAB toolboxes-symbolic math toolbox, control system toolbox, signal processing toolbox and fuzzy logic toolbox.

References:

1. H. C. Saxena, "Finite Differences and Numerical Analysis", S. Chand & Co., New Delhi, 1993.

2. S. C. Gupta & V. K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, New Delhi.
3. Rudra Pratap, "Getting Started with MATLAB 7".
4. The MathWorks Inc., "MATLAB: The Language of Technical Computing".
5. The MathWorks Inc, "SIMULINK: Dynamic System Simulation".
6. The MathWorks Inc., "Sim Power Systems: User's Guide".
7. B. R. Hunt, R. L. Lipsman & J. M. Rosenberg, "A Guide to MATLAB", Cambridge University Press, 2003.
8. O. Beucher and M. Weeks, "Introduction to MATLAB & SIMULINK-A Project Approach", Infinity Science Press LLC, Hingham, MA, Third Edition.

CODE	PEEC 103	L	T	P	Credit
	POWER CONVERTERS	3	1	0	4

UNIT-1:
DC-DC Switched Mode Converters:
Review of Buck Converter, Boost Converter, Buck-Boost, Duty cycle derivation, Different conduction modes (CCM & DCM), Voltage and Current waveforms, Calculation of output voltage ripple.

UNIT-2:
Voltage Source Converters:
3-phase full wave bridge converter, operation and harmonics, Transformer connection for 12 pulse operation, 24 and 48 pulse operation. Operation of 12-pulse converter. 3-level voltage source converter. PWM converter. Generalised technique of harmonic elimination and voltage control. Advanced modulation techniques (SPWM, space vector modulation, 3^{rd} harmonic PWM) Comparison of PWM techniques, Converter rating.

UNIT-3:
Self and Line Commutated Current Source Converter:
Basic concepts and principle of operation of CSC, converters with self commutating devices. Comparison with voltage source converter

UNIT-4:
Resonant Converters:
Switch-mode inductive current switching, Zero Voltage & Zero Current switching , Resonant switch converters, Basic resonant circuit concepts, Resonant switch converters, ZCS and ZVS resonant switch converters , Comparison of ZCS and ZVS topologies. Load resonant converters, resonant switch converters, resonant dc-link Converters, high-frequency-link integral half cycle converters.

UNIT-5:
Multilevel Converters:
Multilevel concept, Types of multilevel converters, diode clamped multilevel converters, flying-capacitors multilevel converters, cascaded multilevel converters, Vienna Converter, applications

switching device currents, d. c. link capacitor voltage balancing, features of multilevel converters, comparison of multilevel converters.

References:

1. K. Kit Sum, “Switch-Mode Power Conversion: Basic theory and design”, Marcel Decker.
2. G. Chryssis, “High Frequency Switching Power supplies: Theory and Design”, Mc Graw Hill.
3. M. H. Rashid, “Power Electronics: Circuits, Devices and Applications”, Prentice Hall of India, 1996.
4. N. Mohan, T. M. Underland and W. P. Robbins, “Power Converters, Applications and Design”, John Wiley & Sons, 1995.
5. G. K. Dubey et al, “Thyristorized Power Controllers”, Wiley Eastern, 1987.
6. B. R. Pelly, “Thyristor Phase Controlled Converters and Cyclo-converters”, Wiley Intersicence, 1971.
7. M. D. Singh and K. B. Khanchandani, “Power Electronics”, Tata McGraw Hill, 2001.
8. V. Subrahmanyam, “Power Electronics”, New Age International Publishers, 1997.
9. D. Grahame Holmes, Thomas A. Lipo, T. A. Lipo “Pulse width modulation for power converters: principles and practice”, Wiley-IEEE press, 2003.

CODE	PEEC 201	L	T	P	Credit
	ADVANCED PROTECTIVE RELAYING	3	1	0	4

UNIT-1:

Introduction to Protection System:

Introduction to protection system and its elements, Functions of protective relaying, Essential qualities of protection, Zones of protection, Primary & backup protection, Classification of relays, Basic protective schemes.

UNIT-2:

Relay Application and Characteristics:

Transfer impedance, Mixing circuits, Amplitude and phase comparators and their duality, Static realization of amplitude and phase comparators, Multi-input comparators, Over-current relays, Directional relays, Distance relays, Differential relay, advanced schemes for protection of transmission lines, alternators, transformers, motors and bus-bars.

UNIT-3:

Static Relays:

Comparison with electromagnetic relay, Classification and their description, Basic construction, Input-output devices, Merits and demerits of static relays, Application of solid state devices.

UNIT-4:

Static Protection:

Over current relaying schemes, Differential relaying schemes, Distance relaying schemes, Power swing and protection of long lines, Protection of multi-terminal lines, New type of relaying criteria, Quadrilateral relay, Elliptical relay, Restricted distance relays.

UNIT-5:

Digital Protection:

Concept of digital protection, Microprocessor based over-current and distance relay schemes, Generalized interface for distance relays.

References:

1. Y. G. Paithankar and S R Bhide, "Fundamentals of Power System Protection", Prentice Hall of India.
2. T. S. M Rao, "Power System Protection: Static Relays with Microprocessor Applications", Tata Mac Graw Hill".
3. A. R. Van C. Warringtaon, "Protective Relays-Their Theory and Practice, Vol. I & II", John Willey & Sons.
4. B. D. Russel and M.I. Council, "Power System Control and Protection", Academic Press, 1982.
5. B. Ravindranath and M. Chander, "Power System Protection and Switchgear Wiley Eastern", 1977.
6. S. S. Rao, "Switchgear and Protection", Khanna Publishers, 1986.
7. B. Ram and D. N. Viswakarma, "Power System Protection and Switchgear", Tata Mc Graw Hill, 1995.

CODE	PEEC 202	L	T	P	Credit
	COMPUTER AIDED POWER SYSTEM ANALYSIS	3	1	0	4

UNIT-1:

Network Matrices:

Evaluation of bus admittance matrix (Y_{BUS}), Bus impedance matrix (Z_{BUS}), Branch impedance matrix (ZBT) and loop Impedance matrix (Z_{LOOP}) by singular and non singular transformations.

UNIT-2:

Short Circuit Studies:

Formulation of Z_{BUS} for single phase and three phase networks, Transformation of network matrices using symmetrical components; Short circuit studies using Z_{BUS}, Y_{BUS} and Z_{LOOP}.

UNIT-3:

Load Flow Studies:

Representation of off-load, on-load tap changing and phase shifting transformers, DC link, Decoupled and fast decoupled methods, Sparsity technique; Introduction to load flow of integrated AC/DC system.

UNIT-4:

Stability Studies:

Network formulation for stability studies for different types of loads (constant impedance, constant current and constant power loads), Digital computer solution of swing equation for single and multi-machine cases using Runge-Kutta and predictor corrector methods, Effects of exciter and governor on transient stability.

UNIT-5:

Voltage Stability and Small-Signal Stability:

Voltage Stability Transmission system characteristics, Generator characteristics, Load characteristics. Introduction of reactive compensating devices. Classification of voltage Stability, voltage stability Analysis, voltage collapse and its Prevention.

Small-Signal Stability-Concept of stability of Dynamic System, Eigen-properties of the State Matrix, Single-machine Infinite Bus System, Power System Stabilizer.

References:

1. G. W. Stagg and A.H.EI-Abiad, “Computer Methods in Power System Analysis”, Mc Graw Hill, 1971.
2. G. I. Kusic, “Computer Sided Power System Analysis”, Prentice Hall International, 1986.
3. L. P. Singh, “Advanced Power System Analysis and Dynamics”, Wiley Eastern.

Department Elective 1

CODE	PEEE 101	L	T	P	Credit
	ADVANCED CONTROL SYSTEMS	3	1	0	4

UNIT-1:
State Space Analysis of Continuous-time LTI System:
Review of state space representation of continuous linear time invariant system, Conversion of state variable models to transfer functions and vice-versa, Transformation of state variables, Solution of state equations, Similarity transformation

UNIT-2:
Controllability and Observability:
State and output controllability and observability, Kalman's and Gilbert's Tests for controllability and Observability

UNIT-3:
Analysis of Discrete-time System:
Discrete time signals and systems, z-transformation, modeling of sample-hold circuit, pulse transfer function, solution of difference equation by z-transform method, stability analysis in z-plane

UNIT-4:
Analysis of Nonlinear System:
Common physical nonlinearities, singular points, phase plane analysis, limit cycles, describing function method and stability analysis, jump resonance, Linearization of nonlinear systems. Lyapunov stability, Methods for generating Lyapunov function, Statement of Lure problem, Circle criterion, Popov's criterion

UNIT-5:
Optimal and Adaptive Control:
Basic concepts of optimal control, Adaptive control, intelligent control and robust control systems.

References:

1. K. Ogata, "Modern Control Engineering", John Wiley & Sons, 2001.
2. Norman S. Nise, "Control System Engineering", John Wiley & Sons, 2001.
3. Kuo B. C., "Digital Control Systems", Saunders College Publishing, 1992.
4. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill, 1997.
5. I. J. Nagrath & M. Gopal, "Modern Control Engineering", New Age International, 2005.
6. S. M. Tripathi, "Modern Control Systems: An Introduction", Jones & Bartellet Publishers, USA, 2009.
7. M. Gopal, "Modern Control System Theory", Wiley Eastern, 1993.
8. K. Ogata, "Discrete Time Control System", Prentice Hall International, 1987.

CODE	PEEE 102	L	T	P	Credit
	POWER SYSTEM PLANNING AND RELIABILITY	3	1	0	4

UNIT-1:

Load Forecasting:

Objectives of forecasting-Load growth patterns and their importance in planning-Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting, Determination of annual forecasting-Use of AI in load forecasting.

UNIT-2:

Generation System Reliability Analysis:

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

UNIT-3:

Transmission System Reliability Analysis:

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT-4:

Expansion Planning:

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT-5:

Distribution System Planning Overview:

Introduction, sub transmission lines and distribution substations, Design of primary and secondary systems-distribution system protection and coordination of protective devices.

References:

1. Roy Billinton & Ronald N. Allan, "Reliability Evaluation of Power System", Springer Publication, 1986.
2. R.L. Sullivan, "Power System Planning", Tata McGraw Hill Publishing Company Ltd, 2012.
3. X. Wang & J.R. McDonald, "Modern Power System Planning", McGraw Hill Book Company, 1994.
4. T. Gonen, "Electrical Power Distribution Engineering", McGraw Hill Book Company, 1986.

CODE	PEEE 103	L	T	P	Credit
	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS	3	1	0	4

UNIT-1:

Introduction:

Concept of reactive power control in electrical power transmission lines, Uncompensated transmission line, Series & shunt compensation, Concept and merits of on line tap changing transformer (OLTC), Phase modifier circuit, Capacitor banks, Inductor banks etc.

UNIT-2:

Static VAR Compensator (SVC) and its Applications:

Voltage control by SVC, Advantages of slope in dynamic characteristics, Influence of SVC on system voltage, Design of SVC voltage regulator, Modeling of SVC for power flow and transient stability, Applications: Enhancement of transient stability, Steady-state power transfer, Enhancement of power system damping, Prevention of voltage instability.

UNIT-3:

Thyristor Controlled Series Capacitor (TCSC) and its Applications:

Operation of TCSC, Different modes of operation, Modeling of TCSC, Variable reactance model, Modeling for power flow and stability studies, Applications: Improvement of the system stability limit, Enhancement of system damping, SSR Mitigation.

UNIT-4:

Voltage Source Converter Based FACTS Controllers:

Static Synchronous Compensator (STATCOM), Principle of operation, V-I Characteristics, Applications: Steady state power transfer, Enhancement of transient stability, Prevention of voltage instability, SSSC, Operation of SSSC, Control of power flow, Modeling of SSSC in load flow and transient stability studies, Applications: SSR Mitigation, UPFC and IPFC.

UNIT-5:

Placement & Co-ordination of FACTS Controllers:

Controller interactions, SVC, SVC interaction, Co-ordination of multiple controllers using linear control techniques, Control coordination using AI techniques (fuzzy / neuro / genetic algorithm).

References:

1. N.G. Hingorani and I. Gyugyi, "Understanding FACTS", IEEE Press, 1999
2. Y. H. Songh and A. T. Johns.ed.,"Flexible AC Transmission Systems (FACTS)", IEEE 1999.
3. R. Mohan Mathur, Rajiv K. Varma, "Thyristor-Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
4. K. R. Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008
5. V. K. Sood, HVDC and FACTS controllers-Applications of Static Converters in Power System, April 2004 , Kluwer Academic Publishers

CODE	PEEE 104	L	T	P	Credit
	DISTRIBUTED GENERATION AND MICRO-GRID	3	1	0	4

UNIT-1:

Introduction:

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass and tidal sources.

UNIT-2:

Distributed Generations (DG):

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT-3:

Impact of Grid Integration:

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT-4:

Microgrids:

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT-5:

Power Quality Issues in Microgrids:

Power quality issues in microgrids-Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

References:

1. Amirnaser Yezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2009.
2. Dorin Neacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, “Solar Photo Voltaics”, PHI learning Pvt. Ltd., New Delhi, 2009.
4. J. F. Manwell, “Wind Energy Explained, theory design and applications,” J. G. McGowan Wiley publication, 2002.
5. D. D. Hall and R. P. Grover, “Biomass Regenerable Energy”, John Wiley, New York, 1987.

6. John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, 2005.

CODE	PEEE 105	L	T	P	Credit
	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	3	1	0	4

UNIT -1:

Introduction to Renewable Energy Sources:

Introduction, importance, classification and qualitative study of different renewable energy resources: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and Hybrid renewable energy systems,

UNIT-2:

Renewable Energy Converters:

Three-phase AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters, matrix converters, Principle of operation: line commutated converters (inversion-mode), Boost and buck-boost converters

Electrical Machines:

Review of reference theory fundamentals, Principle of operation and analysis: SCIG, PMSG, and DFIG.

UNIT-3:

Wind Power Conversion Systems:

Wind power and its sources, wind characteristics, wind power generator, performance and limitations, Stand-alone operation of fixed and variable speed wind energy conversion systems, Grid integrated PMSG and SCIG Based WECSs, Machine side & Grid side controllers, Grid connection Issues related to Wind Systems.

UNIT-4:

Solar Power Conversion Systems:

Theory of solar cells, solar materials, solar cell power plant, limitations, Block diagram of solar photo-voltaic system, selection of inverter, battery sizing, array sizing, Grid Integrated solar system, and Grid connection Issues related to solar systems.

UNIT-5:

Hybrid Renewable Energy Systems:

Need for Hybrid Systems, Range and types of Hybrid systems, Wind-Diesel Hybrid System, Wind-Photovoltaic Hybrid Systems, Photovoltaic-Diesel Hybrid System, Case studies of Wind-PV Maximum Power Point Tracking (MPPT), Grid connection Issues related to hybrid systems.

References:

1. S. N. Bhadra, D. Kastha, S. Banerjee, "Wind Electrical Systems", Oxford Press.
2. Rai. G. D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G. D, "Solar energy utilization", Khanna publishes, 1993.

4. Gray, L. Johnson, “Wind energy system”, Prentice Hall, 1995.
5. B. H. Khan, “Non-conventional Energy sources”, Tata Mc Graw Hill, New Delhi.
6. L. L. Freris, “Wind Energy conversion Systems”, Prentice Hall, 1990
7. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.
8. E. W. Golding, “The generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge, 1976.
9. S. Heir, “Grid Integration of WECS”, Wiley 1998.