SREE VIDYANIKETHAN ENGINEERING COLLEGE
(AUTONOMOUS)
Sree Sainath Nagar, Tirupati
Department of Electrical and Electronics Engineering

Supporting Document for 1.1.3

Courses having focus on

Employability/ Entrepreneurship/ skill Development

Program: **M.Tech.- Electrical Power Systems**

Regulations : **SVEC-19**

The Courses (with course outcomes) under SVEC-19 Regulations which focus on ***employability/ entrepreneurship/ skill development*** are highlighted with the following colours.

Skill

Employability

Entrepreneurship

M. Tech. - I Semester

(19MT10701) HIGH VOLTAGE ENGINEERING

Int. Marks	Ext. Marks	Total Marks		L	T	P	C
40	60	100		3	-	-	3

PRE-REQUISITES: Electromagnetic fields, Electrical Circuits and power syetsm at UG level.

COURSE DESCREPTION: Electrostatic fields and control; Breakdown phenomena of insulation; Generation of high voltages; Measurement of high voltage & current and Testing of high voltage apparatus.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of High Voltage to analyze electric fields, their control and behavior of dielectrics in the presence of fields.

CO2. Analyze the circuits for generation and measurement of High Voltages, current and impulse.

CO3. Realize the philosophy of testing and development procedures for testing of various High Voltage equipment.

DETAILED SYLLABUS:

Unit - I: Electrostatic Fields and Control (6 hours)

Introduction to High voltage Engineering-Electrical field distribution and breakdown strength of insulating materials; Field distortions by conducting particles; Fields in multi-dielectric materials; Numerical methods for electric field computation: Finite Element method, Charge simulation method, Surface charge simulation method; Control of electric field intensity; Optimization of electrode configuration.

Unit - II: Breakdown Phenomena (11 hours)

Classification of HV insulating media; Gaseous Breakdown: Townsend's theory, Streamer's theory, Breakdown in electro negative gases; Paschen's law; Time lags of Breakdown; Insulation coordination. Breakdown in solid dielectrics: thermal breakdown and electro mechanical breakdown; Treeing and Tracking, Internal discharges. Breakdown of liquid dielectrics: Suspended particle theory, stressed oil volume theory.

Unit - III: Generation of High Voltage AC, DC and Generation of Impulse Voltage and Current (12 hours)

Generation of high voltage AC and DC: HVAC-HV transformer; cascade connection of transformers. Series resonant circuit; HVDC- voltage doubler circuit, cock croft- Walton circuit, Tesla coil; Calculation of regulation, ripple and optimum number of stages for minimum voltage drop.
Generation of Impulse Voltage and Current: Introduction to standard lightning and switching impulse voltages; Analysis of single stage impulse generator -expression for output impulse voltage; Multistage impulse

generator working principle-Rating and components of impulse generator; Triggering of impulse generator; Generation of high impulse current.

Unit - IV: Measurement of High Voltage and Current (8 hours)

HVAC measurement-Chubb and Fortescue method; HVDC measurements - Generating voltmeter - Principle, construction; Potential dividers: Resistance dividers, Capacitance dividers, Mixed RC potential dividers; Standard sphere gap measurements of HVAC, HVDC and impulse voltages, Factors affecting the measurements. Measurement of high impulse currents -Rogowsky coil and Magnetic links.

Unit - V: Testing of High Voltage Apparatus (8 hours)

Non-destructive testing: Measurement of DC resistivity-Galvanometer method and loss of charge methods; Dielectric loss and loss angle measurements using Schering Bridge; partial discharge measurements – straight discharge detection circuit.
Testing of High Voltage Apparatus: Testing of insulators, bushings, power transformers, cables, surge arresters and circuit breaker.

Total hours: 45

TEXT BOOKS:

1. E. Kuffel, W.S. Zaengl and J. Kuffel, *High Voltage Engineering: Fundamentals*, Elsevier Press, 2nd edition,, 2000.
2. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Publishing Company Ltd., 4th edition, New Delhi, 2008.

REFERENCE BOOKS:

1. C.L. Wadhwa, *High Voltage Engineering*, New Age Science, *3rd revised edition*, 2010.
2. Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, RoshdyRadwan, *High Voltage Engineering Theory and Practice,* Revised & Expanded, Marcel-Dekker Publishers, 2nd edition, 2000.

M. Tech. - I Semester

(19MT10702) POWER ELECTRONICS FOR POWER SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics Course at UG Level

COURSE DESCREPTION: Power Switch Control Circuits; Multi pulse Controlled Rectifiers; AC Voltage Controllers and Cyclo converters; Analysis of DC-DC and Resonant Converters; Analysis of DC-DC and Resonant Converters

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate in-depth knowledge and analyze the operation of power semiconductor devices as controlled switches.

CO2. Demonstrate in-depth knowledge in operation, analysis and performance evaluation of ac-dc, ac-ac, dc-dc and dc-ac converters.

CO3. Apply the knowledge to select appropriate voltage control techniques to improve the performance of power converter modules, develop desired topology and to initiate research ideas.

DETAILED SYLLABUS:

Unit - I: Power Switch Control Circuits (08 hours)

Review of basic power switching devices. Basic construction and switching characteristics of GTO and IGCT. Gate drive circuits for SCR, MOSFET, IGBT and Base drive circuit for power BJT. Comparison of power devices.

Unit - II: Multi pulse Controlled Rectifiers (10 hours)

Multi pulse rectifiers- six pulse and twelve pulse SCR rectifiers, operation, effect of line and leakage inductance, power factor and THD. 18 and 24 pulse SCR rectifier circuit schemes.
Single phase series converters. Power factor improvement of controlled rectifiers - extinction angle control, symmetric angle control, PWM control-single and three phase control.

Unit - III: AC Voltage Controllers and Cyclo converters (08 hours)

Synchronous tap changers – operation, applications. Three phase AC voltage controllers – operation, analysis of controllers with star and delta connection, applications, numerical problems.
Three phase cycloconverters – three-phase/ single-phase and three-phase/ three-phase cycloconverters, analysis, applications, numerical problems.

Unit - IV: Analysis of DC-DC and Resonant Converters (09 hours)

Switch mode regulators–buck, boost, buck-boost and cuk regulators, condition for continuous inductor current and capacitor voltage - design of LC filter. Multi-output boost converters – advantages, applications, numerical problems. Resonant converters- concept of ZVS and ZCS, principle of operation, analysis of M-type and L-type converters.

Unit - V: DC-AC Converters **(10 hours)**

Voltage control of single phase inverters – single, multiple, sinusoidal, modified sinusoidal pulse width modulation, phase displacement control. Advanced PWM techniques-trapezoidal, staircase, stepped, harmonic injection, delta modulations. Voltage control of three phase inverter-sinusoidal PWM, 60 degree PWM, third harmonic PWM, space vector modulation. Harmonic reduction. Multilevel inverters- principle, operation of cascaded type MLI, applications.

Total hours: 45

TEXT BOOKS:

1. Rashid M.H., *Power Electronics circuits, devices and applications*, Prentice Hall publications, 3rd edition, 2009.
2. Ned Mohan, Undeland and Robbin, *Power Electronics: converters, Application and Design*, John Wiley and sons Inc., Newyork, 1995.

REFERENCE BOOKS:

1. Bin Wu, *High power converters and AC Drives,* John Wiley and Sons, 2006.
2. P.C Sen., *Modern Power Electronics*, Wheeler publishing Co, 1st edition, 1998.

M. Tech. - I Semester

(19MT10703) POWER SYSTEM SECURITY AND STATE ESTIMATION

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power system analysis, Power system operation and Control at UG level

COURSE DESCRIPTION: Power system network matrices; Balanced and unbalanced short circuit analysis; AC and DC Load flow studies; Power system security; Power system state estimation.

COURSE OUTCOMES: on successful completion of the course, student will be able to

CO1. Develop mathematical models of the power system for various power system studies.

CO2. Apply knowledge of power system network matrices to solve various faults in power system.

CO3. Apply knowledge of power system network matrices to evaluate the security of the power system.

CO4. Apply knowledge of power system network matrices to estimate the state of power system.

DETAILED SYLLABUS:

Unit - I: Power System Network Matrices (09 hours)

Formation of bus admittance matrices by direct inspection method and singular transformation method – Algorithm for formation of Bus impedance matrix: addition of a branch and addition of a link, removal element in Bus impedance matrix, Sparsity programming and Optimal Ordering – numerical problems. Π-representation of off-nominal tap transformers.

Unit - II: Fault Analysis (09 hours)

Short circuit studies – introduction, short circuit calculations using Z_{bus}, Z_{fabc}, Y_{fabc}, $Z_{f\ 012}$ and $Y_{f\ 012}$ matrices for various faults. Analysis of balanced and unbalanced three phase faults – simple problems.

Unit - III: Power System Security-I (09 hours)

Review of power flow methods (qualitative treatment only), DC power flow method-simple problems. Introduction to power system security, factors influencing power system security.

Unit - IV: Power System Security-II (08 hours)

Introduction to contingency analysis, Contingency analysis: Detection of Network problems, linear sensitivity factors, AC power flow methods, Contingency selection– simple problems.

Unit - V: State Estimation in Power System (10 hours)

Power system state estimation, SCADA, EMS center, Methods of state estimation – method of least squares, orthogonal matrix, properties, Givens rotation, orthogonal decomposition, Bad data detection, and applications of power system state estimation – simple problems.

Total hours: 45

TEXT BOOKS:

1. Allen J. Wood and Wollenberg B.F., *Power Generation Operation and control*, John Wiley & Sons, 2nd edition, 2006.
2. P. Venkatesh, B.V. Manikandan, S. Charles Raja and A.Srinivasan, Electrical power systems analysis, security, and deregulation, PHI learning private limited, Delhi, 2014.

REFERENCES:

1. Nagrath I.J. and Kothari D.P., Modern Power System Analysis, TMH, New Delhi, 2004.
2. John J. Grainger and William D. Stevenson, Power System Analysis, Tata McGraw-Hill, 2003.

M.Tech. - I Semester

(19MT18304) CONTROL SYSTEM DESIGN

(Program Elective - 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Control systems in UG Level

COURSE DESCRIPTION: Design of compensators and controllers; Controllability and observability of a system; Control systems design using state space; Nonlinear systems.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of Lag, Lead and Lead-Lag compensators to analyze and design the systems in frequency and time domains for the given specifications.

CO2. Demonstrate the knowledge of PD, PI &PID Controllers to develop a suitable controller based on the required time and frequency domain specifications and analyze their performance.

CO3. Apply appropriate methods to solve linear and non-linear systems using state space approach.

CO4. Identify the attributes for analyzing the given non-linear systems.

DETAILED SYLLABUS:

Unit - I: Introduction to Design (09 hours)

The Design Problem, Preliminary considerations of classical design, Realization of Basic Compensators, Design of Lead, Lag and Lag-Lead compensators using root locus technique. Lead, Lag and Lag-Lead compensators design using Bode plot.

Unit - II: Controllers Design (09 hours)

Introduction to controllers, Types of controllers, Effect of P, PI and PID controllers. Design of PI, PD and PID controllers using bode plot and root locus technique.

Unit - III: Controllability and Observability (09 hours)

Review of state variable techniques – Concept of controllability and observability for Continuous Time Systems. Principles of Duality. Controllability and Observability of state models in Jordan canonical form and other canonical forms – effect of state feedback on controllability and observability.

Unit - IV: Design of Control Systems in State Space (09 hours)

Necessity of pole placement, design by pole placement, necessary and sufficient conditions for arbitrary pole placement. Determination of feedback gain matrix using direct substitution method and Ackermann's formula. Full order observer and reduced order observer.

Unit – V: Introduction to Non Linear System (09 hours)

Introduction to non-linear systems, behavior of non linear systems, common physical nonlinearities, describing function method, concept derivation of describing function method, phase plane method, singular points, stability of non linear system, construction of phase trajectories by isocline method.

Total hours: 45

TEXT BOOKS:

1. M. Gopal, *Modern Control System Theory*, New Age International (P) Ltd., 2nd edition, New Delhi, 2005.
2. K. Ogata, *Modern Control Engineering,* Prentice Hall of India, 4th edition,2006.
3. Hasan A. Khalil,*Nonlinear Systems*, Prentice Hall of India, 3rd edition, 2002.

REFERENCE BOOKS:

1. Nagoorkani, *Advanced control theory*, RBA publications, 2nd edition, India, 2009.
2. I.J. Nagrath and M.Gopal, *Control Systems Engineering*, New Age International (P) Ltd., India, 2007.

M. Tech. – I Semester

(19MT18305) INTELLIGENT CONTROLLERS

(Program Elective – 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Engineering Mathematics and Contol systems at UG level.

COURSE DESCRIPTION: Neural Networks; Fuzzy Logic Systems; Genetic Algorithms; Differential Evaluation; Hybrid Intelligent Systems; Swarm intelligence; Applications.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of neural networks and fuzzy logic controllers, evolutionary algorithms in hybrid intelligent controllers to analyze and develop the suitable controller for solving engineering problems.

CO2. Analyze the conceptual knowledge of neural networks and fuzzy logic controllers and various evolutionary algorithms to provide optimal solutions.

DETAILED SYLLABUS:

Unit - I: Neural Networks (10 hours)

Neural network architectures, perceptron model, learning strategies: supervised learning, radial basis function network, back propagation network. unsupervised learning: Kohonen's SOM, reinforced learning, load forecasting using neural networks.

Unit - II: Fuzzy Logic Systems (9 hours)

Fuzzy sets: relations & operations, membership functions, Fuzzification, rule base, Inference mechanism, defuzzification and design of fuzzy control system, speed control of separately excited DC motor using fuzzy logic.

Unit - III: Genetic Algorithms and Differential Evaluation (10 hours)

Genetic algorithms: Introduction to evolutionary computation, Genetic algorithms (GA): biological background, traditional optimization and search techniques, basic terminologies, simple GA, Flow chart, operators in GA, encoding, selection, crossover, mutation, constraints in GA, fitness function, advantages and limitations of GA, optimal allocation of DG using GA.

Differential Evaluation: Overview, initialization, base vector selection, Differential mutation, recombination, selection and Termination criteria.

Unit - IV: Swarm Intelligence (9 hours)

Introduction to swarm intelligence, Swarm intelligence algorithms-Ant colony optimization: Biological and artificial ant colony systems, applications of ant colony intelligence: Static & dynamic combinatorial optimization problems, Algorithm of Ant colony system, Particle swarm optimization: The basic PSO method, characteristic features of PSO, PSO algorithm, Optimum parameter setting for the best performance of PSO, Comparison with other Evolutionary computing techniques, MPPT of PV system by using PSO and Ant-colony.

Unit - V: Hybrid Intelligent Systems (7 hours)

Introduction to hybrid intelligent systems: Adaptive neuro-fuzzy Inference Systems, Architecture and learning. Fuzzy GA systems: rules generation. ANN Learning Using GA: Optimization of weights, Load forecasting problem using Neuro-fuzzy approach.

Total hours: 45

TEXT BOOKS:

1. S. N. Sivanandam, S.N. Deepa, *Principles of Soft Computing*, *Wiley–India Edition*, 2008.
2. N.P. Padhy, *Artificial Intelligence and Intelligent Systems*, *Oxford University press*, 10th reprint, 2011.

REFERENCE BOOKS:

1. Saroj Kaushik, *Artificial Intelligence*, Cengage Learning India Private Limited, Fifth Indian reprint, 2013.
2. J.S.R. Jang, C.T. Sun, E. Mizutani, *Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, Pearson Education Taiwan Limited, 2004.
3. Fakhreddine O. karray, Clarence De Silva, *Soft computing and Intelligent systems Design, Theory, tools and applications*, *Pearson Education Limited*, 2009.
4. Kenneth V. Price · Rainer M. StornJouni A. Lampinen, *Differential Evolution, A Practical Approach to Global Optimization*, Springer, 2005.

M.Tech. – I Semester

(19MT18306) MICROCONTROLLER AND APPLICATIONS

(Program Elective - 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Digital logic design, Microprocessors at UG level.

COURSE DESCRIPTION: PIC Microcontroller: Architecture, Peripherals, Programming, Interfacing and Applications.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the knowledge of PIC Microcontroller and its internals and use appropriate tools to program it for the control of systems.

CO2. Interface the peripherals and control them by programming the PIC microcontroller through MPLAB, PIC 'C' Compiler etc.,

DETAILED SYLLABUS:

Unit - I: PIC Microcontrollers (9 hours)

Microcontrollers and Embedded processors, Overview of PIC18 family, CISC vs RISC. Harvard vs Von Neumann architectures. PIC18architecture and features. PIC18 Memory organization – program memory, data memory. PIC18 Register file – General purpose registers and SFRs.

Unit - II: PIC 18 Basic Programming and Tools (9 hours)

Introduction to PIC18 Assembly Programming, PIC18 Data Format and Directives. PIC18 programming tools. Instruction set – data transfer, arithmetic, logical, bit manipulation, branch Instructions. Addressing modes – Immediate, Direct, Register Indirect Addressing Modes. Macros and Modules. PIC18 programming using MPLAB and PIC 'C' Compiler.

Unit - III: Timers, Serial Port and I/O Ports programming(9 hours)

Timer –Programming Timers 0 and 1 in Assembly language, Programming Timers 2 and 3 in Assembly language, Serial Port – Basics of Serial Communication and PIC Serial Port programming in Assembly language. I/O Ports – Port A TRISA, Port B TRISB, Port C TRISC, Port D and Port E.

Unit - IV: Interrupts, CCP and ECCP Programming (9 hours)

PIC18 Interrupts, Programming Timer Interrupts, Programming the Serial Communication Interrupts, Port-B - Change Interrupt, Interrupt Priority in the PIC18. Standard and Enhanced CCP Modules, Compare Mode programming, Capture Mode programming, PWM Programming, ECCP Programming.

Unit - V: PIC Interfacing **(9 hours)**

ADC Characteristics, ADC Programming in the PIC18, DAC Interfacing, Sensor Interfacing and Signal Conditioning, Relays and Opto-isolators, Stepper Motor Interfacing, DC Motor Interfacing and PWM, PWM Motor Control with CCP, DC Motor Control with ECCP.

Total hours: 45

TEXT BOOKS:

1. Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey, *PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18*, Pearson Education, India, 2008.
2. John B. Peatman, *Design with PIC Microcontrollers*, Pearson Education, India, 2007.

REFERENCE BOOKS:

1. PIC18C MCU Family Reference Manual, Microchip.
2. John B. Peatman, *Embedded design with the PIC18F452 Microcontroller*, Prentice Hall, 2003.

M. Tech. – I Semester

(19MT10704) HIGH VOLTAGE DC TRANSMISSION

(Program Elective - 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics and Power Systems at UG level

COURSE DESCRIPTION: HVDC Transmission: Capabilities, Applications and planning; Analysis and control of power converter; Harmonics and Filters; Types of Multi-Terminal DC Systems and control; Faults and Protection.

COURSE OUTCOMES: on successful completion of the course, student will be able to

CO1. Demonstrate the knowledge on HVDC transmission systems, MTDC systems and to analyze and control static power converters.

CO2. Analyze harmonics, filters, faults and protection schemes in HVDC Transmission system.

CO3. Design and develop various types of filters to suppress harmonics in HVDC systems.

DETAILED SYLLABUS:

Unit - I: Introduction to HVDC Transmission (10 hours)

HVDC Transmission – Comparison of HVAC and HVDC transmission, types of DC Links, power handling capabilities of HVDC lines, applications of HVDC Transmission, planning for HVDC transmission, modern trends in DC Transmission, basic conversion principles.

Unit - II: Static Power Convertor Analysis and Control (10 hours)

Static Power Converters: Static converter configuration- 6 pulse & 12 pulse converters, converter station and terminal equipment, rectifier and inverter operation, converter bridge characteristics, equivalent circuit for converter.

Control of HVDC converter: Principle of DC link control – constant current, constant extinction angle and constant ignition angle control. Individual phase control and equidistant firing angle control.

Unit - III: Harmonics and Filters (09 hours)

Generation of harmonics in HVDC systems, methods of harmonics elimination, harmonic instability problems, Causes for instability, remedies for instability problems. Design of AC filters, single frequency tuned filter, Double frequency tuned filter, high pass filter, cost consideration of AC harmonic filter, DC filters.

Unit - IV: Multi-Terminal DC Links and Systems (08 hours)

Introduction – Potential applications of MTDC systems – Types of MTDC systems – series, parallel and series-parallel systems, their principle of operation and control - Protection of MTDC systems.

Unit - V: Faults and Protection (08 hours)

Over voltages due to disturbance on DC side, over voltages due to DC and AC side line faults – Converter faults, over current protection– Valve group and DC line protection. Over voltage protection of converters – Surge arresters.

Total hours: 45

TEXT BOOKS:

1. K.R.Padiyar, *High Voltage Direct current Transmission*, New Age International (P) Ltd, Publishers, 2004.
2. S. Rao, *EHV-AC, HVDC Transmission & Distribution Engineering*, Khanna Publishers, 2006.

REFERENCE BOOKS:

1. E. Uhlman, *Power Transmission by Direct Current*, Springer Verlag, Berlin, 2000.
2. E. W. Kimbark, *Direct current Transmission*, John Wiely& sons, New York,1971.
3. J. Arillaga, *HVDCTranmission*, peter peregrilnus Ltd., London UK, 1983.

M. Tech. – I Semester

(19MT18307) ELECTROMAGNETIC FIELD COMPUTATION AND MODELING

(Program Elective-2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Electromagnetic fields and Electrical Machines at UG level.

COURSE DESCRIPTION: Review of basic field theory; Basic solution methods for field equations; Formulation of finite element method; Computation of basic quantities using FEM packages; Design applications.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of Electromagnetic fields to analyze various electrical field problems using analytical and numerical methods.

CO2. Demonstrate the knowledge in computation of electrical parameters using Finite Element Method.

CO3. Provide solutions to design electrical equipment.

DETAILED SYLLABUS:

Unit - I: Introduction (9 hours)

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion –energy and co-energy-force/torque calculation.

Unit - II: Basic Solution Methods for Field Equations (9 hours)

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods-Finite Difference Method.

Unit - III: Formulation of Finite Element Method (FEM) (9 hours)

Variational Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems.

Unit - IV: Computation of Basic Quantities Using FEM Packages (6 hours)

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

Unit - V: Design Applications **(12 hours)**

Electromagnetic field analysis of Magnetic actuators, transformers, switched reluctance motors, three phase induction motors.

Total hours: 45

TEXT BOOKS:

1. Matthew. N.O. Sadiku, *Elements of Electromagnetics*, Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. Nicola Biyanchi , *Electrical Machine analysis using Finite Elements*, Taylor and Francis Group, CRC Publishers, 2005.

REFERENCE BOOKS:

1. Nathan Ida, Joao P.A.Bastos, *Electromagnetics and calculation of fields*, Springer Verlage, 1992.
2. S.J Salon, *Finite Element Analysis of Electrical Machines,* Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, India.
3. User manuals of MAGNET, MAXWELL & ANSYS software.

M. Tech. - I Semester

(19MT10705) DIGITAL SIGNAL PROCESSING

(Program Elective – 2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Engineering Mathematics and Signal & Systems.

COURSE DESCRIPTION: Discrete-time signals and systems; Discrete Fourier series, Discrete Fourier Transforms (DFT) and Fast Fourier Transform (FFT) algorithms for the analysis of discrete time sequences; design and realization of Digital IIR and FIR filters; implementation of Park's and Clark's transformation using LF240X processor; DSP based implementation of DC-DC buck-boost converters.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge of digital signals and systems to analyze DFT and FFT techniques.

CO2. Apply the knowledge of analog and digital filters to design and realize IIR and FIR filters using different techniques.

CO3. Apply DSP controllers for buck-boost converter, control of motors and further extend to real time application.

DETAILED SYLLABUS:

Unit -I: Discrete Time Signals and Systems (8 hours)

Review of discrete time signals and systems; Review of Z-transforms, Solutions for difference equation of discrete time systems; frequency response of discrete time signals; A/D and D/A conversion; Introduction to DSP system with block diagram.

Unit -II: Frequency Transformations (9 hours)

Introduction to DFT – Properties of DFT, relation between DFT and Z-transforms, linear convolution, Circular Convolution. FFT Algorithms – Decimation in time Algorithms, Decimation in frequency Algorithms, inverse DFT.

Unit -III: IIR Filter Design (10 hours)

Digital Vs Analog filters, Analog low pass filter design: Butterworth and chebyshev low pass filters. Design of IIR filter from analog filters using Impulse Invariance and Bilinear transformation techniques. Frequency transformation in digital domain. Realization of Digital filters - Direct form–I and Direct form–II structures.

Unit-IV: FIR Filter Design (8 hours)

Linear phase FIR filters and its frequency response; location of zeros in linear phase FIR filters; Fourier series method of design of FIR filters.

Design of FIR filters using windows - Rectangular, Triangular, Hamming, Hanning and Blackmann windows.

Unit -V: DSP Applications **(10 hours)**

Introduction to peripherals-types of physical memory-software used (Preliminary approach). DSP based implementation of DC-DC buck boost converters – introduction, converter structure, continuous and discontinuous conduction modes, connecting DSP to buck-boost converter, controlling the buck-boost converter. Field Oriented Control (FOC) transformations, implementing Clarke's and Park's Transformations on the LF240X.

Total hours: 45

TEXT BOOKS:

1. Anand kumar, *Digital signal processing*, PHI Learning Private limited, New Delhi, 2013.
2. Hamid A. Toliyat, Steven G. Campbell, *DSP based electromechanical motion control*, CRC Press Special Indian edition, 2012.

REFERENCE BOOKS:

1. Nagoorkani, *Digital signal processing*, 2nd Edition, TMH Education Pvt., Ltd., 2012.
2. Alan.V. Oppenheim, Ronald.W. Schafer, John R Buck, *Discrete Time Signal Processing*, Prentice Hall, 2nd edition, 2006.

M.Tech. – I Semester

(19MT10706) POWER QUALITY

(Program Elective - 2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics, Electric Machines at UG level

COURSE DESCRIPTION: Power Quality concepts; harmonics and power quality standards and monitoring; power quality enhancement using custom power devices; power quality issues in distributed generation.

COURSE OUTCOMES: on successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of power quality and it's standards to analyze, monitor and mitigate various power quality issues.

CO2. Apply the knowledge of filters to mitigate harmonic distortion due to industrial and commercial loads.

CO3. Apply the conceptual knowledge of various custom power devices to enhance power quality for specific applications.

CO4. Demonstrate the conceptual knowledge of distributed generation to analyze the power quality issues in power systems.

DETAILED SYLLABUS:

Unit - I: Fundamentals of Power Quality (10 hours)

Definition of power quality, classification of power quality issues, power quality standards, categories and characteristics of electromagnetic phenomena in power systems: impulsive and oscillatory transients, interruption, sag, swell, sustained interruption, under voltage, over voltage, outage. sources and causes of different power quality disturbances.

Unit - II: Harmonics & Applied Harmonics (10 hours)

Harmonic distortion, voltage vs current distortion, harmonics vs transients, power system qualities under non sinusoidal conditions, harmonic indices, harmonic sources from commercial loads, harmonic sources from industrial loads. applied harmonics: effects of harmonics, harmonic distortion evaluations, principles of controlling harmonics, devices for controlling harmonic distortion.

Unit - III: Power Quality Monitoring (08 hours)

Power quality benchmarking, monitoring considerations, choosing monitoring locations, permanent power quality monitoring equipment, historical perspective of power quality measuring instruments, power quality measurement equipment-types of instruments, assessment of power quality measurement data, power quality monitoring standards.

Unit - IV:Power Quality Enhancement Using Custom Power Devices (09 hours)

Introduction to Custom Power Devices-Network Reconfiguring Type: Solid State Current Limiter (SSCL) - Solid State Breaker (SSB) - Solid State Transfer Switch
(SSTS). Compensating Type: Dynamic Voltage Restorer, Distribution STATCOM and Unified Power Quality Conditioner –operation, realization and control of DVR, DSTATCOM and UPQC – load compensation.

Unit - V: Power Quality Issues in Distributed Generation (08 hours)

DG Technologies, Perspectives on DG benefits- Interface to the Utility System - power quality issues affected by DG - Operating Conflicts: Utility fault-clearing, Reclosing, Interference with relaying, Voltage regulation issues, Islanding - siting DG.

Total hours: 45

TEXT BOOKS:

1. Roger C. Dugan, Mark E. Mc. Granaghan, Surya Santosoh and H. Wayne Beaty, *Electrical Power Systems Quality,* 2nd edition, TATA McGraw Hill, 2010.
2. Arindam Ghosh, Gerard Ledwich, *Power Quality Enhancement Using Custom Power Devices*, Springer, 2002.

REFERENCE BOOKS:

1. Math H J Bollen, *Understanding Power Quality Problems: Voltage Sags and Interruptions,* Wiley, 2010.
2. C. Sankaran, *Power Quality*, CRC press, 2000.

M.Tech. - I Semester

(19MT10707) SMART GRIDS

(Program Elective - 2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Systems and at UG level.

COURSE DESCRIPTION: Concept of smart grid; various information and communication technologies for Smart Grid; Smart metering; Demand side integration; Energy management systems.

COURSE OUTCOMES: After successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of smart grid and communication technologies to analyze fault levels and to estimate the state of the system.

CO2. Apply
- Modern techniques to integrate renewable energy sources to power system.
- Information security tools for secured operation of smart grid.

DETAILED SYLLABUS:

Unit - I: Smart Grid (05 hours)

smart grid introduction, ageing assets and lack of circuit capacity, thermal constraints, operational constraints, security of supply, national initiatives, early smart grid initiatives, active distribution networks, virtual power plant, other initiatives and demonstrations, overview of the technologies required for the smart grid.

Unit - II: Transmission and Distribution Management (09 hours)

Data Sources, Energy Management System, Wide Area Applications, Visualization Techniques, Data Sources and Associated External Systems, SCADA, Customer Information System, Modeling and Analysis Tools, Distribution System Modeling, Topology Analysis, Load Forecasting, Power Flow Analysis, Fault Calculations, State Estimation, Applications, System Monitoring, Operation, Management, Outage Management System, Overview of energy storage technologies.

Unit - III: Smart Metering and Demand Side Integration (11 hours)

Introduction, smart metering – evolution of electricity metering, key components of smart metering, smart meters: an overview of the hardware used – signal acquisition, signal conditioning, analogue to digital conversion, computation, input/output and communication. Communication infrastructure and protocols for smart metering - Home area network, Neighborhood Area Network, Data Concentrator, meter data management system, Protocols for communication. Demand Side Integration- Services

Provided by DSI, Implementation of DSI, Hardware Support, Flexibility Delivered by Prosumers from the Demand Side, System Support from DSI.

Unit - IV: Communication Technologies for The Smart Grid (11 hours)

Data Communications: Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching, Communication Channels, Introduction to TCP/IP
Communication Technologies: IEEE 802 Series, Mobile Communications, Multi-Protocol Label Switching, Power line Communication.

Unit - V: Information Security for The Smart Grid (09 hours)

Introduction, Encryption and Decryption, Symmetric Key Encryption, Public Key Encryption, Authentication, Authentication Based on Shared Secret Key, Authentication Based on Key Distribution Center, Digital Signatures, Secret Key Signature, Public Key Signature, Message Digest.

Total Hours: 45

TEXT BOOKS:

1. Janaka Ekanayake, Kithsiri Liyanage, et.al. *Smart Grid Technology and Applications*, Wiley Publications, 2012.
2. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, IEEE Press, 2012.
3. Bharat Modi, Anuprakash, Yogesh Kumar, *Fundamentals of Smart Grid Technology*, S.K Kataria& Sons, 2015.

REFERENCE BOOKS:

1. Eric D. Knapp, Raj Samani, *Applied Cyber Security and the Smart Grid-Implementing Security Controls into the Modern Power Infrastructure*, Syngress Publishers, 2013.
2. Nouredine Hadjsaid, Jean Claude Sabonnadiere, *Smart Grids*, Wiley Blackwell Publications.
3. Peter-Fox Penner, *Smart Power: Climate Changes, the Smart Grid, and the future of electric utilities,* Island Press, 1st edition,2010.

M. Tech. - I Semester

(19MT10708) RESEARCH METHODOLOGY AND IPR

(Common to all M. Tech. Programs)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	2	-	-	2

PRE REQUISITES:

COURSE DESCRIPTION: Overview of research; research problem and design; various research designs; Data collection methods; Statistical methods for research; Interpretation & drafting reports and Intellectual property rights.

COURSE OUTCOMES: On successful completion of the course, student will be able to:

CO1. Apply the conceptual knowledge of research methodology to formulate the hypothesis, data collection and processing, analyzing the data using statistical methods, interpret the observations and communicating the novel findings through a research report.

CO2. Practice ethics and have responsibility towards society throughout the research process and indulge in continuous learning process.

CO3. Apply the conceptual knowledge of intellectual property rights for filing patents and trade mark registration process.

DETAILED SYLLABUS:

Unit - I: Introduction to research methodology (07 hours)

Objectives and Motivation of Research, Types of Research, Defining and Formulating the Research Problem; Features of research design, Different Research Designs; Different Methods of Data Collection, Data preparation and Processing.

Unit - II: Data Analysis and Hypothesis (09 hours)

ANOVA; Principles of least squares-Regression and correlation; Normal Distribution- Properties of Normal Distribution; Testing of Hypothesis – Hypothesis Testing Procedure, Types of errors, t-Distribution, Chi-Square Test as a Test of Goodness of Fit.

Unit - III: Interpretation and report Writing (04 hours)

Interpretation – Need, Techniques and Precautions; Report Writing – Significance, Different Steps, Layout, Types of reports,Mechanics of Writing a Research Report, Precautions in Writing Reports; Research ethics.

Unit - IV: Introduction to intellectual property and trade Marks (07 hours)

Importance of intellectual property rights; types of intellectual property, international organizations; Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

Unit - V: Law of Copyrights **(08 hours)**

Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer

New Developments in IPR: Administration of Patent System.

Total hours: 35

TEXT BOOKS:

1. C.R. Kothari, *Research Methodology: Methods and Techniques*, New Age International Publishers, 2nd revised edition, New Delhi, 2004.
2. Deborah, E. Bouchoux, *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*, Cengage learning, 5th edition, 2017.

REFERENCE BOOKS:

1. R. Panneerselvam, *Research Methodology*, PHI learning Pvt. Ltd., 2009.
2. Prabuddha Ganguli, *Intellectual property right - Unleashing the knowledge economy*, Tata McGraw Hill Publishing Company Ltd, 2001

M. Tech. – I Semester

(19MT10731) HIGH VOLTAGE ENGINEERING LAB

Int. Marks	Ext. Marks	Total Marks		L	T	P	C
50	50	100		-	-	4	2

PRE-REQUISITES: High Voltage Engineering at PG level.

COURSEDESCREPTION: Practical investigations on Breakdown mechanisms in dielectrics materials; Generation & measurement of high DC, AC, impulse voltages and testing high voltage apparatus.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of High Voltage to analyze behavior of dielectrics in the presence of fields practically and relate the physical observation to validate the underlying theoretical concepts.

CO2. Analyze the circuits for generation and measurements of High Voltages, current and impulse through experimental procedures.

CO3. Realize the philosophy of testing and develop procedures to test a High Voltage equipment.

CO4. Apply ethics and norms of the engineering practice while exercising experimental investigations.

CO5. Function effectively as an individual to accomplish the given task effectively.

CO6. Communicate effectively in verbal and written forms.

List of Experiments: Minimum of **ten** experiments to be conducted.

1. Electric field and stress analysis by using 2-D Ansoft software.
2. Generation of HVDC and lightning Impulse voltages.
3. Dielectric characteristics of gaseous dielectrics under uniform and non-uniform electric fields.
4. Dielectric characteristics of liquid dielectrics under uniform and non-uniform electric fields.
5. Dielectric characteristics of solid dielectrics under uniform and non-uniform electric fields.
6. Verification of Paschen's law.
7. Measurement of Earth resistance.
8. Measurement of HVAC and HVDC and impulse voltages using sphere gap.
9. Determination of string efficiency of suspension type insulator.
10. Determination of 50% critical Impulse flash-over voltages on the 11 kV Insulator with Positive Impulse and Negative Impulse.
11. Power frequency withstand test on ceramic and composite insulators.
12. Treeing and tracking phenomenon.

M. Tech. - I Semester

(19MT10732) POWER SYSTEM ANALYSIS - I LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Power system security and state estimation at PG level and Power electronics, Control systems at UG level

COURSE DESCRIPTION: Simulation investigations on various advanced power system operation and control networks and Power electronics converters.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge to analyze and evaluate the performance and behavior of power electronics converters and power system network during normal & adverse conditions using domain specific tools.

CO2. Realize the philosophy of simulating, testing and develop procedures to test the various standard power systems networks and power electronic circuits in industry and society.

CO3. Apply ethics and norms of the engineering practice while exercising experimental investigations.

CO4. Function effectively as an individual to accomplish the given task effectively.

CO5. Communicate effectively in verbal and written forms

List of Exercises: Conduct minimum of **Ten** Exercises from the following

1. Analysis of short, medium and long Transmission lines.
2. Formation of bus admittance matrix.
3. Formation of Bus Impedance matrix.
4. Load flow studies.
5. Computation of Available Transfer Capabilities.
6. Contingency analysis.
7. Fault analysis using Bus impedance matrix.
8. State estimation using Weighted Least Square, linear and non-linear methods.
9. Analysis of controllers and observers for power system applications.
10. Measurement of Real and Reactive power in grid connected system.
11. Three phase fully controlled Rectifier.
12. Three phase inverter with PWM controller.
13. Buck and Boost converter for power system applications.
14. Resonant converter for power system applications.
15. Five level cascaded Multi-level inverter.
16. Single phase grid connected PV System with MLI.
17. Mini Project

M. Tech. - I Semester
(19MT1AC01) TECHNICAL REPORT WRITING
(Audit Course)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	2	-	-	-

PRE-REQUISITES : -

COURSE DESCRIPTION: Introduction; Process of writing; Style of writing; Referencing; Presentation.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1: Demonstrate knowledge of Technical Report Writing by examining kinds of reports and structure with scientific attitude.

CO2: Apply the techniques in preparing effective reports by examining Techniques of Description, Describing Machines and Mechanisms and Describing Processes.

CO3: Communicate effectively through writing technical reports by demonstrating the knowledge of Industry Reports, Survey Reports, Interpretive Report and Letter Report.

DETAILED SYLLABUS:

Unit - I: Introduction (6 hours)

Introduction to Technical Report - Types of Reports - Planning Technical Report Writing - Components of a Technical Report - Report Writing in Science and Technology - Selecting and Preparing a 'Title' - Language Use in Report Writing.

Unit - II: Process of Writing (5 hours)

Writing the 'Introduction' - Writing the 'Materials and Methods' - Writing the Findings/Results' - Writing the 'Discussion' - Preparing and using 'Tables'.

Unit - III: Style of Writing (6 hours)

Preparing and using Effective 'Graphs' - Citing and Arranging References—I - Citing and Arranging References —II - Writing for Publication in a Scientific Journal.

Unit - IV: Referencing (9 hours)

Literature citations - Introductory remarks on literature citations - Reasons for literature citations – Bibliographical data according to ISO - Citations in the text - Copyright and copyright laws - The text of the Technical Report - Using word processing and desktop publishing (DTP) systems - Document or page layout and hints on editing -Typographic details - Cross-references.

Unit - V: Presentation (4 hours)

Giving the presentation-Appropriate pointing-Dealing with intermediate questions-Review and analysis of the presentation-Rhetoric tips from A to Z.

Total hours: 30

TEXT BOOKS:

1. R C Sharma – Krishna Mohan, *Business Correspondence and Report Writing,*Tata McGraw-Hill Publishing Company Limited, New Delhi, Third Edition, 2005 (reprint).
2. Patrick Forsyth*, How to Write Reports and Proposals,*THE SUNDAY TIMES (Kogan Page), New Delhi, Revised Second Edition, 2010.

REFERENCE BOOKS:

1. John Seely, *The Oxford Writing & Speaking*, Oxford University Press, Indian Edition.
2. Anne Eisenberg, *A Beginner's Guide to Technical Communication*, McGraw Hill Education (India) Private Limited, New Delhi, 2013.

M. Tech. – II Semester

(19MT20701) POWER SYSTEM MODELING AND CONTROL

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Electrical machines, control systems, power system analysis at UG level and Power system security and state estimation PG level.

COURSE DESCRIPTION: Introduction to the synchronous machine classical model; state space models of synchronous machine; Methods of Excitation systems and modeling ; Effect of excitation on stability; Analysis of Voltage stability.

COURSE OUTCOMES: After successful completion of the course, student will be able to

CO1. Demonstrate in depth knowledge in analyzing and evaluating the performance of regulated and unregulated single machine connected to infinite bus system with one time lag.

CO2. Use appropriate transformation techniques to model synchronous machine.

CO3. Represent the excitation systems, apply and analyze various control schemes to them.

CO4. Apply various control strategies to analyze the performance of excitation system stability.

CO5. Demonstrate knowledge on voltage and rotor angle stability, use various advance control techniques for analyzing the single machine connected to infinite bus system.

DETAILED SYLLABUS:

Unit - I: Classical Model of Synchronous Machine (10 hours)

A Classical model of one machine connected to infinite bus – Problems. System Response to small Disturbances: Types of problems studied, Block diagram of unregulated and regulated synchronous Machine, methods of studies – Effect of small changes of speed. Regulated synchronous machine – voltage regulator with one time lag – Governor with one time lag Classical model of multi-machine system – Modes of oscillation of unregulated Multi machine system – Problems

Unit - II: The Synchronous Machine Model (10 hours)

Introduction – Clarkes's and Park's Transformation – flux linkage equations, self and mutual inductances of stator and rotor, transformation of inductances, voltage equations. Formulations of state space model of one machine system connected to infinite bus, voltage, current equations.

Unit - III: Excitation Systems (08 hours)

Simplified view of excitation control, control configuration. Excitation

system response -Non-continuously regulated systems, and continuously regulated systems. Excitation system compensation- state space description of the excitation system - simplified linear model only.
Types of Excitation systems: Type -1 system: Continuously acting regulator, Type - 2 system: rotating rectifier system, Type - 3 system: Static with terminal potential and current supplies, Type-4system: non–continuous acting - Block diagram representation – state space representation.

Unit - IV: Effect of Excitation on Stability (08 hours)

Introduction – effect of excitation on generator power limits – effect of the excitation system on transient stability, effect of excitation on dynamic stability – examination of dynamic stability by routh's criterion. Block diagram of the linear generator with exciter, supplementary stabilizing signals, approximate model of the complete exciter-generator system, Lead compensation.

Unit - V: Voltage Stability Analysis (11 hours)

Voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage in stability collapse – Control of voltage instability.
Review of Lyapunov's stability theorems of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Quadratic forms – Variable gradient method – Zubov's method – Popov's method, Lyapunov function for single machine connected to infinite bus.

Total hours: 45

TEXT BOOKS:

1. P.M.Anderson, A.A.Fouad, *Power System Control and Stability*,IEEE Press, 2nd edition, 2003.
2. K.R.Padiyar, *Power System Dynamics (Stability & Control)*, B.S.Publications, 2nd edition, India, 2008.

REFERENCES:

1. Prabha Kundur, Neal J. Balu, Mark G. Lauby, *Power System Stability and Control*, McGraw-Hill, 2nd edition,1994.
2. M.A.Pai, *Power System Stability – Analysis by the direct method of Lyapunov*, North Holland Publishing Company, Newyork, 1981.
3. Venkataramana Ajjarapu*, Computational Techniques for Voltage Stability Assessment and Control,* Springer US, 2007

M. Tech. - II Semester

(19MT20702) STATIC AND DIGITAL PROTECTION OF POWER SYSTEM

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power systems and Microprocessors at UG level.

COURSE DESCRIPTION: Introduction to Static and Digital Relays; Comparators; Static Over Current and Differential Relays; Static Distance Relays;Microprocessor Based Protective Relays.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Demonstrate knowledge on static and digital relays to analyze different protection schemes.

CO2. Apply the knowledge of various components of static relay to design an appropriate protection scheme for power system.

CO3. Apply the knowledge of numerical relays to design and analyze microprocessor based relay for power system protection.

DETAILED SYLLABUS:

Unit - I: Introduction to Static and Digital Relays (08 hours)

Static Relays - basic construction and advantages. Level detectors, Replica impedance, Mixing circuits, Phase and Amplitude Comparators – General equation for two input phase and amplitude comparators, Duality between Phase and Amplitude Comparators.
Numerical Relays: Block diagram of typical Numerical Relay – Advantages and Disadvantages.

Unit - II: Comparators (08 hours)

Amplitude comparators: Circulating current type, opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators.
Phase comparators: Coincidence circuit type-block spike phase comparator, techniques to measure the period of coincidence–Integrating type–Rectifier and vector product type phase comparators.
Multi–Input comparators: Conic section characteristics–Three input amplitude comparator–Hybrid comparator.

Unit - III: Static Over Current and Differential Relays (10 hours)

Static over current relays: Introduction, Instantaneous over current relay – Time over current relays. Basic principles – Definite time, Inverse Definite time and Directional over current relays.
Static Differential Relays: Analysis of Static differential relays – static relay schemes – Duo bias transformer differential protection – Harmonic restraint relay.

Unit - IV: Static Distance Relays (10 hours)

Static impedance, Reactance, MHO and angle impedance relays – sampling

comparator –realization of reactance and MHO relays using a sampling comparator.
Power Swings: Effect of power swings on the performance of distance relays, Power swing analysis, Principle of out-of-step tripping and blocking relays, effect of line length and source impedance on distance relays.

Unit - V: Microprocessor Based Protective Relays (09 hours)

Microprocessor based over current relays, Impedance relay, Directional relay, Reactance relay, and flowcharts. Generalized mathematical expression for distance relays, measurement of resistance and reactance, MHO and offset-MHO relays –Realization of MHO characteristics, realization of offset MHO characteristics and flow charts – Microprocessor Implementation of Digital distance relaying algorithms – Mann-Morrison technique, Differential equation technique.

Total hours: 45

TEXT BOOKS:

1. T.S. Madhava Rao, *Power system Protection - Static relays with Microprocessor Applications*, Tata McGraw Hill Publishing Company limited, 2nd edition, 2008.
2. Badri Ram and D. N. Vishwakarma, *Power system Protection and Switchgear*, Tata McGraw Hill Publication Company limited, 2nd edition 2013.

REFERENCE BOOKS:

1. Bhuvanesh A Oza, Nirmal Kumar C Nair, Rashesh P Mehta, Vijay H Makwana, *Powersystem protection and switchgear*, Tata McGraw Hill Education Private Limited, 2010.

M. Tech. – II Semester

(19MT28305) SOLAR ENERGY CONVERSION SYSTEMS

(Program Elective - 3)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics and control systems UG level.

COURSE DESCRIPTION: Solar energy conversion system; Types of photovoltaic systems – Stand-alone, hybrid and grid connected systems; Energy storage systems; Applications.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge on solar cell and analyze the behavior of solar cells for different irradiations.

CO2. Apply the knowledge of solar modules, energy storage system and mptt to design the stand-alone and grid connected pv systems for various real time applications.

DETAILED SYLLABUS:

Unit - I: Photovoltaic Basics (09 hours)

Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays – open circuit (Voc) and short circuit characteristics of a PV array- Basics of Load Estimation.

Unit - II: Stand alone PV System (09 hours)

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing.

Unit - III: Grid Connected PV Systems (09 hours)

Schematics, Components, solar converters –state of charge characteristics (SOC) - Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings-Micro Grid structure.

Unit - IV: Design of PV Systems (09 hours)

Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

Unit - V: Applications (09 hours)

Water pumping, Battery chargers, Solar car, Direct-drive applications, Space and Telecommunications.

Total hours: 45

TEXT BOOKS:

1. Solanki C.S., *Solar Photovoltaics: Fundamentals, Technologies and Applications*, PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, *Applied Photovoltaics*, Earthscan, 2007.
3. Earthscan, U K.Eduardo Lorenzo G. Araujo, *Solar electricity engineering of photovoltaic systems*, Progensa, 1994.

REFERENCE BOOKS:

1. Frank S. Barnes, Jonah G. Levine, *Large Energy storage Systems Handbook*, CRC Press, 2011.
2. Mc Neils, Frenkel, Desai, *Solar & Wind Energy Technologies*, Wiley Eastern, 1990.
3. S.P. Sukhatme, *Solar Energy*, Tata McGraw Hill, 1987.
4. Nikos Hatziargyriou - *Microgrids- Architectures and control* , Wiley, IEEE press, 2013.

M. Tech. - II Semester

(19MT20703) EHVAC TRANSMISSION

(Program Elective – 3)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITE(S): Power Systems at UG level

COURSE DESCRIPTION: Concept of EHVAC transmission; analysis and design of EHVAC lines; effects of EHVAC; Corona Effects; voltage control and compensation.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Demonstrate knowledge, analyze and evaluate the various configurations of EHVAC transmission lines parameters and line losses.

CO2. Demonstrate knowledge in computing the voltage gradient of conductors and electric fields.

CO3. Demonstrate knowledge in computing the corona effects, power losses and analyze the audible & radio interference in EHVAC transmission lines.

CO4. Demonstrate knowledge in evaluating the electrostatic fields and safety measures for human, animals, and plants.

CO5. Demonstrate knowledge, skills to analyze and evaluate the various voltage control techniques and compensation techniques in EHVAC transmission lines.

DETAILED SYLLABUS:

Unit - I: Transmission Line Trends and Preliminaries (10 hours)

Role of EHV AC transmission. Power handling capacity and line loss, costs of transmission lines and equipment. Mechanical considerations in line performance – numerical problems.
Line and Ground parameters: Calculation of resistance of conductors. Properties of bundled conductors - bundle spacing, bundle radius and geometric mean radius of bundle. Inductance of EHV line configurations – Inductance of two conductors, multi-conductor lines (Maxwell's co-efficient) and bundled conductor lines. Line Capacitance calculation - sequence inductances and capacitances – line parameters for modes of propagation, ground return – numerical problems.

Unit - II: Voltage Gradients of Conductors (10 hours)

Electrostatics, field of sphere gap, field of line changes and their properties, charge - potential relations for multi-conductors. Surface voltage gradient on conductors - distribution of voltage gradient on sub conductors of bundle - numerical problems.

Unit - III: Corona Effects (10 hours)

Power loss: corona loss formulae, charge-voltage (Q-V) diagram.
Audible noise (AN): generation, characteristics, limits and measurements of AN, relation between 1-phase and 3-phase AN levels – numerical problems.
Radio interference (RI): Corona pulses - generation, properties and frequency spectrum. Limits for radio interference fields. Lateral profiles of RI and modes of propagation, excitation function, measurement of RI, RIV and excitation functions – numerical problems.

Unit - IV: Electrostatic Fields (10 hours)

Electrostatic field: calculation of electrostatic field of EHV lines, effect on humans, animals and plants - electrostatic induction in un-energized circuit of double-circuit line - electromagnetic interference – numerical problems.

Unit – V: Power-Frequency Voltage Control and Over Voltages (05 hours)

No-load voltage conditions and charging currents, voltage control – synchronous condenser, shunt and series compensation. Static VAR compensation – numerical problems.

Total hours: 45

TEXT BOOKS:

1. Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, New Age International Pvt. Ltd, 3rd edition, 2006.

REFERENCE BOOKS:

1. S. Rao, EHVAC, HVDC Transmission and Distribution Engineering, Khanna Publications, 2001.
2. Edison Electric Institution (GEC), EHV Transmission line reference Book, Edison House, 1968.

M. Tech. - II Semester

(19MT20704) POWER SYSTEM AUTOMATION

(Program Elective –3)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power system at UG level.

COURSE DESCRIPTION: Power system operation and control, Substation and Energy management systems (EMS) for control centers, Distribution automation.

COURSE OUTCOMES: On successful completion of the course, students will be able to:

CO1. Demonstrate knowledge on real time operation and control of power system

CO2. Examine operational technical issues in power system, substation and distribution systems to provide feasible solutions, substation and distribution systems.

CO3. Demonstrate knowledge on various models of restructuring power system and analyze various forecasting methods for pricing and operation of deregulated power system.

DETAILED SYLLABUS:

Unit - I: Power System Control (08 hours)

Introduction, Decomposition, Operation of power systems, Organization and operator activities, Investment factor, Control centre, Elements of computer control system.

Unit - II: Power System Automation (10 hours)

Evolution of automation systems, SCADA in Power system, Building blocks of SCADA system, Remote terminal Unit, Intelligent electronic devices, Data concentrators and merging Unit s, SCADA communication systems, Master station, Human-machine interface, Classification of SCADA systems.

Unit - III: Substation Automation (09 hours)

Substation automation, conventional automation, New smart devices for substation automation, New integrated digital substation, Technical issues, New digital simulation. Substation automation architectures, Substation automation applications functions, Benefits of data warehousing.

Unit - IV: Energy management systems (EMS) for control centers (10 hours)

Introduction , Energy control centers, EMS framework Data acquisition and communication (SCADA systems), Generation operation and management, Transmission operations and management: Real time, Study-mode Simulations, Post-event analysis and energy scheduling and accounting, Dispatcher training simulator, Smart transmission.

Unit - V: Distribution Automation (08 hours)

Introduction to Distribution automation - Customer, Feeder and substation automation, Subsystems in a distribution control center, Distributed Management System (DMS) framework integration with subsystems, advanced real-time DMS applications, Advanced analytical DMS applications, DMS coordination with other systems.

Total hours: 45

TEXT BOOKS:

1. Torsten cegrell, *Power systems control Technology*, Prentice Hall, 1^{st} edition, 1986.
2. Mini S Thomas and John D Mcdonald, *Power System SCADA and Smart Grids*, CRC Press, 1^{st} edition, 2015.
3. M Shahidehpour, Muwaffaq Alomoush, *Restructured electrical power systems operation, trading and volatility*, CRC Press, 1^{st} edition, 2001.

REFERENCE BOOKS:

1. James Northcote-Green and Robert Wilson, *Control and Automation of Electrical Power Distribution Systems*, CRC Press, 1^{st} edition, 2013.
2. Edmund Handschin, *Real time control of Electric Power System*, Elsevier Publishing company, 1^{st} edition, 1972.

M.Tech. – II Semester

(19MT20705) REACTIVE POWER COMPENSATION AND MANAGEMENT

(Program Elective - 3)

Internal Marks	External Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITE(S): Power systems and control systems at UG level

COURSE DESCRIPTION: Reactive Power compensation:Ideal compensator; Line and load compensation ; Compensating devices; Reactive power coordination; Quality of power supply; Distribution side management; Reactive power management in domestic and industrial sectors.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge on reactive power compensation techniques, demand side management and power quality issues in steady state and transient state at domestic and industrial sectors.

CO2. Apply the knowledge of various compensators to analyze, design and solve various reactive power problems in domestic and industrial sectors.

CO3. Demonstrate knowledge on reactive power coordination, power tariffs, to select location and appropriate size of capacitor.

CO4. Apply ethics in quality of supply and norms of reactive power compensation and management.

DETAILED SYLLABUS:

Unit - I: Reactive Power Compensation (09 hours)

Need for Reactive Power compensation – reactive power characteristics. Ideal compensator, practical compensation – power factor correction and voltage regulation. Load compensator as a voltage regulator, phase balancing and power factor correction of unsymmetrical loads – examples.

Unit - II: Reactive Power Compensation in Transmission System (09 hours)

Steady state Reactive power compensation – Uncompensated line, Types of compensation, Passive shunt, series and dynamic shunt compensation – examples. **Transient state Reactive power compensation** – Characteristic time periods. Passive shunt compensation. Static compensations–series capacitor compensation, compensation using synchronous condensers - examples

Unit - III: Reactive Power Coordination and Planning (09 hours)

Reactive power coordination: Objectives, Mathematical modeling, Operation planning, transmission benefits. Basic concepts of quality of power supply:

Disturbances, steady – state variations, effects of under voltages, frequency, Harmonics, radio frequency and electromagnetic interferences. Reactive power planning: Objectives, Economics Planning capacitor placement and retrofitting of capacitor banks.

Unit - IV: Reactive Power Management (09 hours)

KVAR requirements for domestic appliances: Purpose of using capacitors, selection of capacitors, deciding factors. Types of available capacitors – characteristics and limitations, Control of capacitors. Demand side management: Load patterns, basic methods load shaping, power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels - System losses, loss reduction methods - examples.

Unit - V: Reactive Power Management in Industrial Sectors

(09 hours)

Typical layout of traction systems–reactive power control requirements. Electric arc furnaces, textile and plastic industries, furnace transformer, filter requirements, remedial measures, and power factor of an arc furnace, minimum capacitance required for excitation.

Total hours: 45

TEXT BOOKS:

1. T.J.E. Miller, *Reactive power control in Electric power systems*, A Wiley–Inter science publications, New York, 1982.
2. D.M. Tagare, *Reactive power Management*, Tata McGraw-hill publishing company Ltd., New Delhi, 2004.

REFERENCE BOOK:

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, *Reactive power compensation: A Practical Guide,* Willey, April, 2012.

M. Tech. – II Semester

(19MT28309) WIND ENERGY CONVERSION SYSTEMS

(Program Elective - 4)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITE(S): Power Electronics, control systems in UG level.

COURSE DESCRIPTION: Fundamentals of wind energy and its measurement; wind turbine design and basic aerodynamics principles; need of usage of wind generators; wind turbine control, monitor and implementation in the wind farm and site selection; power quality issues and mitigation methods of wind power integration in the power system.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. demonstrate knowledge on various components, types, characteristics and measurements of wind turbines.

CO2. apply the knowledge of aerodynamics forces to analyze wind turbine blade rotation.

CO3. use the knowledge of various design procedures and converters for designing modern wind turbines and to integrate.

CO4. demonstrate knowledge on various types of control and monitoring techniques used in WECS.

CO5. demonstrate knowledge on power quality problems in WECS and apply suitable mitigation techniques/ custom power devices to improve the power quality.

DETAILED SYLLABUS:

Unit - I: Wind Energy Fundamentals and Measurements (08 hours)

wind power scenario in India; basics of wind characteristics: extractable limits of wind power; estimation of wind power potential; gust/extreme wind speeds; wind turbulence wind measurement and instrumentation; horizontal/vertical axis wind turbines; wind turbine components, braking, yaw system, tower.

Unit - II: Design and Aerodynamics of Wind Turbine (10 hours)

Analysis of semi Review on basic aerodynamics, Airfoils and General Concepts of Aerodynamics, types and characteristics of wind turbine, Blade Design for Modern Wind Turbines, blade element theory, Betz limit, Generalized Rotor Design Procedure, turbine design: Design procedure, topologies , Wind Turbine Standards, Technical Specifications, and Certification, Wind Turbine Design Loads, power curve prediction.

Unit - III: Wind Turbine Generators (09 hours)

Fixed speed and variable speed systems, Electrical machines for wind energy systems, synchronous and asynchronous generators and its performance, Integration of wind energy systems to electrical networks, converters, inverters, directly connected, wind energy storage solutions.

Unit - IV: Wind Turbine Control, Testing and Applications(12 hours)

Types of Control Systems in Wind Turbines, Overview of Wind Turbine Control Systems, Typical Grid-connected Turbine Operation, and Typical Constant-speed and variable speed Operating Schemes, Supervisory Control Overview Implementation, overview of testing methods.

Applications: hybrid power systems, special purpose applications, overview of energy storage, site selection and environmental impacts.

Unit - V: Power Quality Issues in Integration of WECS (06 hours)

Stand alone and Grid connected wind systems, Power Quality issues, Impact of power quality problems on WECS, Harmonic reduction and Power factor improvement, Mitigation of power quality problems, and role of custom power devices in Distributed Generation.

Total hours: 45

TEXT BOOKS:

1. J. F. Manwell, J. G. McGowan and A. L. Rogers, *Wind Energy Explained –Theory, Design and Application,* Wiley, 2009.
2. G.D. Rai, *Non - Conventional Energy Resources*, Khanna Publishers, 2002.

REFERENCE BOOKS:

1. V. Daniel Hunt*, Wind power: a handbook on wind energy conversion systems,* Van Nostrand Reinhold Co., 1981, Khanna Publishers, 4th Edition,New Delhi, 2012.
2. Arindam Ghosh, Gerard Ledwich, *Power Quality Enhancement Using Custom power devices Power Devices,* Springer, 2002.
3. Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso and H. Wayne Beaty, *Electrical Power Systems Quality,* TATA McGraw Hill, 2nd edition, 2008.

M. Tech. – II Semester

(19MT20706) FLEXIBLE AC TRANSMISSION SYSTEM

(Program Elective – 4)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics and Power Systems at UG level.

COURSE DESCRIPTION: Need for flexible AC transmission systems; objectives of shunt and series compensations, phase angle regulators; FACTS controllers: shunt, series and combined; coordination of various FACTS controllers.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the conceptual knowledge of compensation techniques and appropriate conventional and FACTS devices for active and reactive power flows in parallel and meshed systems.

CO2. Analyze the active and reactive power flow, transient stability enhancement, power oscillation damping and optimal operation through various FACTS devices/controllers and their coordination.

DETAILED SYLLABUS:

Unit - I: Introduction to AC Transmission Systems (7 hours)

Overview of interconnected power system. Power flow in AC systems – Expression for real and reactive power flow between two nodes of a power system, controllable parameters. Power flow in parallel and meshed system. Overview of compensated transmission lines – shunt and series compensation. Conventional controllers for real and reactive power flows – merits and demerits. FACTS –benefits, types of FACTS controllers.

Unit - II: Static Shunt Compensation (10 hours)

Expression for real and reactive power flow with mid-point voltage regulation. Variable impedance type static VAR generators - V-I characteristics and control schemes of TCR, TSR, TSC. QD-QO characteristic and control scheme of TSC-TCR. Switching converter type VAR generators – V-I characteristics and control schemes of STATCOM. Hybrid VAR generators – V-I characteristics of SVC and STATCOM, regulation of V-I slope. Applications of static shunt compensators – Voltage regulation, improvement in transient stability, prevention of voltage instability, power oscillation damping. Comparison of static shunt compensators.

Unit - III: Static Series Compensation (10 hours)

Expression for real and reactive power flow with series line compensation. Variable impedance type series compensators: V-I characteristics and control schemes of GCSC, TSSC, TCSC- modes of operation. Sub-synchronous resonance. Switching converter type series compensator – V-I characteristics, internal and external control schemes of SSSC. Applications of static series compensators – improvement in transient stability, power oscillation damping. Comparison of static series compensators.

Unit - IV: Static Phase Angle Regulators and Combined Compensators (10 hours)

Power flow control by phase angle regulators - Concept of voltage and phase angle regulation. Operation and control of TCVR and TCPAR. Switching converter type phase angle regulators. Objectives of TCPAR - improvement of transient stability, power oscillation damping. UPFC – Principle, expression for real and reactive power between two nodes of UPFC, independent real and reactive power flow control using UPFC, control schemes of UPFC - operating principle and characteristics of IPFC.

Unit - V: Co - ordination of FACTS Controllers (8 hours)

FACTS controller interactions – interaction between multiple SVC's – interaction between multiple TCSC's – SVC-TCSC interaction – Coordination of multiple controllers using linear control techniques. Comparative evaluation of different FACTS controllers: performance comparison and cost comparison.

Total hours: 45

TEXT BOOKS:

1. Narain G. Hingorani, Laszi Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, Wiley-IEEE Press, 1999.
2. R. Mohan Mathur and Rajiv k. Varma, *Thyristor based FACTS Controllers for Electrical Transmission Systems*, Wiley-IEEE Press, 2002.

REFERENCE BOOKS:

1. Xiao-Ping Zhang, ChristianRehtanz, BikashPal, *Flexible AC Transmission Systems: Modeling and Control*, Springer Power Systems Series, 2006.
2. T.J.E. Miller, *Reactive Power Control in Electric Systems*, Wiley, 1982.

M. Tech. – II Semester

(19MT20707) POWER SYSTEM DEREGULATION

(Program Elective – 4)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power system analysis at UG level

COURSE DESCRIPTION: Features of Restructured Power systems; Market models; Information and transmission services; Electricity pricing and forecasting; Ancillary services management.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the conceptual knowledge of deregulation for various market models, electricity pricing, forecasting methods and ancillary service management in competitive market.

CO2. Analyze market models to provide power exchange, regulate congestion in tie-lines and design various forecasting methods for pricing, planning and operation of deregulated power systems.

DETAILED SYLLABUS:

Unit - I: Overview of Key Issues In Electric Utilities (08 hours)

Introduction: Deregulation, need for deregulation, Advantages of deregulation in power system. Restructuring Models: PoolCo Model, Bilateral Model, Hybrid Model: independent system operator (ISO), Role of ISO. Power exchange, market operations, market power, standard cost, transmission pricing, congestion pricing and management of congestion.

Unit - II: Market Models In Restricted Power Systems (08 hours)

Introduction: Market models based on contractual arrangements: Monopoly model, Single buyer model, Wholesale competition model, Retail competition model. Comparison of various market models. Market architecture: Day-ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts (TCCs), and Ancillary service market.

Unit - III: Oasis: Open Access Same-Time Information System (09 hours)

Structure of OASIS: Functionality and Architecture of OASIS, information requirement of OASIS, Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation. Transmission Services, Methodologies to Calculate ATC.

Unit - IV: Electricity Pricing - Volatility, Risk and Forecasting (10 hours)

Electricity pricing: introduction, electricity price volatility, electricity price indexes. Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves. Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves: Short term Price Forecasting, Factors

Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors.

Unit - V: Ancillary Services Management (10 hours)

Introduction: Types of ancillary services, Classification of ancillary services, Load-generation balancing related services: Frequency regulation, Load following, Spinning reserve services. Voltage control and reactive power support services: Generators, Synchronous condensers, Capacitors and inductors, SVCs, STATCOMs- Black start capability service.

Total hours: 45

TEXT BOOKS:

1. Kankan Bhattacharya, Math H.J. Buller, Jalap E. Daladier, *Operation of Restructured PowerSystem*, Kluwer Academic Publisher, 2001.
2. Mohammad Shahidehpour, and MuwaffaqAlomoush, - *Restructured Electrical Power Systems – Operation, Trading and Volatility,* Marcel Dekker, Inc. 2001.

REFERENCE BOOK:

1. Loi Lei Lai, *Power system Restructuring and Deregulation*, John Wiley & Sons Ltd., England, 2001.

M. Tech. – II Semester

(19MT20708) POWER SYSTEM PLANNING AND RELIABILITY

(Program Elective – 4)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power systems at UG level.

COURSE DESCRIPTION: Load forecasting; Fundamentals of Reliability Engineering; Evaluation of Power system operating capacity reserve; Evaluation of Frequency and Duration Techniques; Reliability Analysis of Interconnected Systems; Power Distribution System Reliability Analysis.

COURSE OUTCOMES: After successful completion of the course, student will be able to

CO1. Demonstrate the conceptual knowledge of forecasting and apply load forecasting techniques to predict load demand under normal and adverse weather conditions.

CO2. Use conceptual knowledge of probability techniques in analyzing, designing and evaluating the various network configurations.

CO3. Apply conceptual knowledge of probability techniques for solving power system reliability indices.

CO4. Apply conceptual knowledge of capacity outage probability table for solving interconnected power system reliability problems.

CO5. Apply conceptual knowledge of reliability networks in solving power distribution system reliability problems.

DETAILED SYLLABUS:

Unit - I: Power System Planning (06 hours)

Objectives of system Planning - Long term, medium term and short term planning - stages in planning and design, Transition from planning to operation. Overview of transmission and distribution planning.

Unit - II: Load Forecasting (08 hours)

Objectives of forecasting, Factors affecting Load Forecasting - Load Forecasting Methods – Extrapolation, Co-Relation Techniques, Peak Load Forecasting, Weather sensitive load forecasting, Non - Weather sensitive load forecasting, Determination of annual forecasting, Reactive Load Forecasting.

Unit - III: Fundamentals of Reliability Engineering (09 hours)

Introduction to Probability Concept, Random variables, Probability Density and Distribution functions – Probability Distributions: time dependent and independent.

Network and Markov Modeling: redundant and non redundant configuration – complex systems – conditional probability approach, Decomposition Method, cut-set, tie-set approaches – Markov chain – Markov Process, STPM, LSP – one, two model.

Unit - IV: Evaluation of Generating Capacity Reserve, Frequency and Duration Techniques (12 hours)

Introduction – Generation system model – determination of capacity outage probability table – Identical Unit s – Non-Identical Unit s – Determination of transitional rates – deterministic and probabilistic criteria – Sequential addition method – Recursive relation for Unit addition, Unit removal - LOLP, LOLE, EIR.
Frequency and Duration Techniques: Frequency and duration concepts – Two components repairable model (with & without identical components) – Evaluation of cumulative probability and cumulative frequency by using recursive relation

Unit - V: Reliability Analysis of Interconnected Systems and Distribution Systems (10 hours)

Introduction–probability array method in two interconnected systems–evaluation technique – equivalent assisting approach – factors affecting interconnections, effect of tie capacities, tie lines.
Distribution system reliability system analysis – Basic indices – Customer oriented indices – Load and energy indices – Active and Passive failures – Problems on above indices.

Total hours: 45

TEXT BOOK

1. Roy Billinton and Ronald N Allen, *Reliability Evaluation of Power Systems*, Springer, 2nd edition, New York, 1996.
2. R.L. Sullivan, *Power System Planning*, Tata McGraw Hill Publishing Company Ltd, 1977.

REFERENCES:

1. Roy Billinton and Ronald N Allen, *Reliability Evaluation of Engineering Systems*, Springer, 2nd Edition,NewYork, 2013.
2. X. Wang & J.R. McDonald, *Modern Power System Planning* – McGraw Hill Book Company, 1994

M. Tech. - II Semester

(19MT20731) POWER SYSTEM ANALYSIS – II LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Power systems analysis, Power system operation and control at UG level and Power system modeling and control at PG level.

COURSE DESCRIPTION: Simulation investigations on various advanced power system operation and control networks and Power electronics converters.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge to analyze and evaluate the performance and behavior of power electronics converters and power system network during normal & adverse conditions using domain specific tools.

CO2. Realize the philosophy of simulating, testing and develop procedures to test the various standard power systems networks and power electronic circuits in industry and society.

CO3. Apply ethics and norms of the engineering practice while exercising experimental investigations.

CO4. Function effectively as an individual to accomplish the given task effectively.

CO5. Communicate effectively in verbal and written forms.

Practical Exercises : Conduct minimum of **Ten** Exercises from the following

1. Transient Response due to capacitor switching.
2. Transformer inrush currents measurement.
3. Economic load dispatch problem with transmission losses.
4. Analysis of Short circuit studies with and without fault impedance.
5. Load frequency control problem for interconnected power systems with controllers.
6. Voltage instability analysis.
7. Stability analysis of SMIB.
8. Simulation of FACTS controllers (TCR and TCSC).
9. Characteristics and Coordination of Relays.
10. Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)
11. Harmonic analysis and Single tuned filter design to mitigate harmonics.
12. Harmonic analysis and Double tuned filter design to mitigate harmonics.
13. Application of fuzzy logic controller in power system using MATLAB.
14. Application of Neural network in power system using MATLAB.
15. Demonstration of MATLAB tool boxes (GA, PSO etc.) for power system applications.
16. Mini Project

M. Tech. – II Semester

(19MT20732) POWER SYSTEMS AND PROTECTION LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Static and Digital protection of power system at PG level

COURSE DESCRIPTION: Experimental investigations on Three and Two winding transformers, synchronous machine, Relay testing, fault analysis, power angle characteristics, measurement of power quality.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of various Protective relay testings and analyze their performance characteristics.

CO2. Apply the conceptual knowledge to measure and analyze various sequence parameter of transformers, synchronous machines,.

CO3. Apply conceptual knowledge to measure and analyze various types of faults and harmonics.

CO4. Function effectively as an individual and as a member in a team to accomplish the given task effectively.

CO5. Prepare laboratory reports that clearly communicate experimental information.

CO6. Function effectively as an as a member in a team to solve various problems.

List of Experiments: Conduct any **Ten** Experiments from the following

1. Determination of equivalent Impedances of a three winding transformer.
2. Determination of Sub-transient Reactance of Salient Pole Synchronous Machine.
3. Determination of Sequence Impedances of Synchronous Machine.
4. Determination of Sequence Components of o three phase transformer.
5. Fault Analysis
   a. LG and LL Faults.
   b. LLG and LLLG Faults.
6. Power Angle Characteristic of Three-Phase Salient Pole Synchronous Machine.
7. Reactive power measurement using Tap changing transformer.
8. Analysis of Transmission line.
9. Testing of Buchholz relay
10. Characteristics of Over Current Relay.
11. Characteristics of Over Voltage Relay.
12. Characteristics of Percentage Biased Differential Relay.
13. Testing of Frequency Relay.
14. Testing of Reverse Power Relay.
15. Testing of Earth fault Relay
16. Power quality analyzer

M. Tech. – II Semester

(19MT2AC01) STATISTICS WITH R

(Audit Course)

(Common to All M. Tech. Programs)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	2	-	-	-

PRE-REQUISITES: A course on Statistics.

COURSE DESCRIPTION: Concepts of R programming basics, Bivariate and multivariate data, Confidence intervals, Goodness of fit, Analysis of variance.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Import, manage, manipulate, and structure data files using R programming.

CO2. Implement models for statistical analysis of a given dataset and visualize the results to identify trends, patterns and outliers in data.

DETAILED SYLLABUS:

Unit - I: Introduction (5 Hours)

Data, R's command line, Variables, Functions, The workspace, External packages, Data sets, Data vectors, Functions, Numeric summaries, Categorical data.

Unit - II: Bivariate and Multivariate Data (7 Hours)

Lists, Data frames, Paired data, Correlation, Trends, Transformations, Bivariate categorical data, Measures of association, Two-way tables, Marginal distributions, Conditional distributions, Graphical summaries, Multivariate data - Data frames, Applying a function over a collection, Using external data, Lattice graphics, Grouping, Statistical transformations.

Unit - III: Populations (6 Hours)

Populations, Discrete random variables, Random values generation, Sampling, Families of distributions, Central limit theorem, Statistical Inference - Significance tests, Estimation, Confidence intervals, Bayesian analysis.

Unit - IV: Confidence Intervals (6 Hours)

Confidence intervals for a population proportion, *p* - population mean, Other confidence intervals, Confidence intervals for differences, Confidence intervals for the median, Significance test - Significance test for a population proportion, Significance test for the mean (t-tests), Significance tests and confidence intervals, Significance tests for the median.

Unit - V: Goodness of Fit **(6 Hours)**

The chi-squared goodness-of-fit test, The multinomial distribution, Pearson's χ^2-statistic, chi-squared test of independence and homogeneity, Goodness-of-fit tests for continuous distributions, ANOVA - One-way ANOVA, Using *lm* for ANOVA.

Total Hours: 30

TEXT BOOKS:

1. John Verzani, *Using R for Introductory Statistics*, CRC Press, 2nd Edition, 2014.
2. Sudha G Purohit, Sharad D Gore, Shailaja R Deshmukh, *Statistics Using R*, Narosa Publishing house, 2nd Edition, 2015.

REFERENCE BOOKS:

1. Francisco Juretig, *R Statistics Cookbook*, Packt Publishing, 1st Edition, 2019.
2. Prabhanjan N. Tattar, Suresh Ramaiah, B. G. Manjunath, *A Course in Statistics with R*, Wiley, 2018.

M. Tech. – III Semester
(19MT30731) INTERNSHIP

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	100	100	-	-	-	2

PRE-REQUISITES: --

COURSE DESCRIPTION: Aequaint students with the industrial environment; Create competent professionals for the industry; Gain professional experience and understand engineer's responsibilities and ethics.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Develop problem solving skills, critical thinking skills though designing and developing solutions for complex problems.

CO2. Utilize appropriate modern tools and techniques for implementing the proposed solutions.

CO3. Discern various challenges in developing solutions for complex problems, design and conduct experiments to evaluate alternative solutions for the chosen engineering problems.

CO4. Function effectively as an individual and participate well as a team member to build professional network for growth in career.

CO5. Develop communication, enrich professional, interpersonal and technical skills pertaining to the internship experience.

CO6. Understand the industry/organization customs and practices that will help to develop a solid work ethic and professional demeanor, as well as a commitment to ethical conduct and social responsibility.

CO7. Utilize real work experiences to explore their interests, career alternatives that will help with future education or employment through and develop professional skills and competencies to engage in lifelong learning.

M. Tech. – III Semester

(19MT30732) PROJECT WORK PHASE - I

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	-	10

PRE-REQUISITES: --

COURSE DESCRIPTION: Identification of topic for the project work, Literature survey, Collection of preliminary data, Critical study and analysis of the topic identified, Time and cost analysis.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply contextual knowledge to identify a domain of interest and a specific problem in core and allied areas of discipline.

CO2. Conduct a systematic literature review, analyze, cognize and comprehend the extracted information to recognize the current status of research pertinent to the chosen problem.

CO3. Discern various issues, challenges and identify alternative solutions for the chosen engineering problems.

CO4. Function effectively as an individual to recognize the opportunities in the chosen domain of interest and engage in independent learning.

CO5. Write and present a substantial technical report/document to present the findings on the chosen problem.

CO6. Acquire intellectual integrity through understanding the need for ethics in research, profession and its impact on the society.

M. Tech. – IV Semester

(19MT40731) PROJECT WORK PHASE - II

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
150	150	300	-	-	-	16

PREREQUISITES: Project Work Phase – I

COURSE DESCRIPTION: Identification of topic for the project work; Literature survey; Collection of preliminary data; Identification of implementation tools and methodologies; Performing critical study and analysis of the topic identified; Time and cost analysis; Implementation of the project work; Writing of thesis and presentation.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Investigate, conceptualize and design optimal solutions for the chosen engineering problems.

CO2. Utilize appropriate modern tools and techniques for implementing the proposed solution.

CO3. Design and conduct experiments, visualize, analyze and interpret results to test and evaluate the proposed solution.

CO4. Function effectively as an individual to recognize the opportunities in the chosen domain of interest and engage in independent learning.

CO5. Write and present a substantial technical report/document to present the findings on the chosen problem.

CO6. Acquire intellectual integrity through understanding the need for ethics in research, profession and its impact on the society.

CO7. Engage in lifelong learning for development of technical competence in the advanced fields of Power Systems to contribute to the development of scientific/technological knowledge.