SREE VIDYANIKETHAN ENGINEERING COLLEGE

(AUTONOMOUS)

Sree Sainath Nagar, Tirupati

Department of Electrical and Electronics Engineering

Supporting Document for 1.1.2

Syllabus Revision carried out in 2019

Program: M.Tech.- Electrical Power Systems

Regulations : SVEC-19

This document details the following:

1. Courses where syllabus has been changed 20% and more.
2. Course-wise revised syllabus with changes highlighted.

Note: *For SVEC-19 revised syllabus, SVEC-16 (previous syllabus) is the reference.*

List of Courses where syllabus has been changed (20% and more)

Course Code	Name of the course	Percentage of Syllabus changed	Page Number in which Details are Highlighted
19MT10702	Power Electronics for Power Systems	100	3
19MT18304	Control System Design	100	5
19MT18305	Intelligent Controllers	25	7
19MT18307	Electromagnetic Field Computation and Modeling	100	11
19MT10705	Digital Signal Processing	100	13
19MT10706	Power Quality	20	15
19MT10708	Research Methodology and IPR	100	19
19MT10731	High Voltage Engineering Lab	25	21
19MT10732	Power System Analysis - I Lab	25	23
19MT1AC01	Technical Report Writing	100	25
19MT28305	Solar Energy Conversion Systems	100	27
19MT20704	Power System Automation	100	29
19MT28309	Wind Energy Conversion Systems	100	31
19MT20708	Power System Planning and Reliability	40	33
19MT20731	Power System Analysis - II Lab	30	37
19MT20732	Power Systems and Protection Lab	25	39
19MT2AC01	Statistics with R	100	41
	Average	**70**	
	Total No. of Courses in the Program	28	
	No. of Courses where syllabus (more than 20%) has been changed	17	
	Percentage of Syllabus changed in the Program	**42.5**	

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Sree Vidyanikethan Engg. College
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TIRUPATI - 517 102, A.P., India.

PRINCIPAL

PRINCIPAL
SREE VIDYANIKETHAN ENGINEERING COLLEGE
(AUTONOMOUS)
Sree Sainath Nagar, A. RANGAMPET
Chittoor (Dist.) - 517 102, A.P., INDIA.

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

(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 (09hours)

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. SarojKaushik, *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 EducationTaiwan 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. II-Semester
16MT20702: INTELLIGENT SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Engineering Mathematics, Electrical Machines & Power Systems at UG level.

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

COURSE OUTCOMES: On successful completion of the course, student will be able to
CO1. demonstrate knowledge on soft computing techniques.
CO2. analyze complex engineering problems with intelligent techniques.
CO3. solve electrical engineering problems using intelligent systems.
CO4. initiate research related to applications of soft computing in the fields of electrical engineering and allied areas.
CO5. select and apply suitable intelligent techniques for engineering problems.

DETAILED SYLLABUS:

UNIT - I:NEURAL NETWORKS (11Periods)
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: FUZZYLOGICSYSTEM (11Periods)
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 fuzzylogic.

UNIT - III:GENETIC ALGORITHMS (10 Periods)
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, Economic load dispatch using GA.

UNIT - IV: HYBRIDINTELLIGENTSYSTEM (12Periods)
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.

UNIT - V:SWARMINTELLIGENCE (11Periods)
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, Engineering application of ANT colony intelligence in unit commitment problem

Total Periods: 55

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, 10^{th} Reprint, 2011.

REFERENCE BOOKS:

1. SarojKaushik, *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.

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: IIRFilter 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. Anandkumar, *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: onsuccessful 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. II-Semester
16MT20708: POWER QUALITY

(Professional Elective - 2)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Distribution of Electric Power and Power Electronics at UG level

COURSE DESCRIPTION: Power Quality concepts; harmonics and voltage regulation using conventional methods; 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. demonstrate knowledge on

- various power quality issues and mitigationtechniques,
- operational issues in distributedgeneration.

CO2.analyze

- harmonic distortion due to commercial and industrialloads,
- the suitability of various custom powerdevices.

CO3. evaluate various power qualityindices.

CO4. initiate research to develop/design new schemes andtechniques forpower quality enhancement.

CO5. apply the appropriate principles and techniques for integration of distributed generation and utilities.

DETAILED SYLLABUS:

UNIT - I: FUNDAMENTALS OFPOWERQUALITY (12 Periods)

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, overvoltage and outage. Sources and causes of different power qualitydisturbances.

UNIT - II: HARMONICS &APPLIEDHARMONICS (12 Periods)

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: VOLTAGE REGULATION USING CONVENTIONAL METHODS (08 Periods)

Principles of regulating the voltage, devices for voltage regulation: utility step-voltage regulators, ferro-resonant transformers, magnetic synthesizers, on-line UPS systems, motor-generator sets, static VAR compensators, shunt capacitors, series capacitors.

UNIT - IV: POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES(13 Periods)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 (DVR), Distribution STATCOM and Unified Power Quality Conditioner (UPQC): operation, realization and control of DVR, DSTATCOM and UPQC, load compensation. Power quality monitoring, Power quality monitoring standards.

UNIT - V: POWER QUALITY ISSUES INDISTRIBUTEDGENERATION (10 Periods)
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 - sitingDG.

Total Periods: 55

TEXT BOOKS:

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso 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

(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. PrabuddhaGanguli, *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

16MT10731: HIGH VOLTAGE ENGINEERING LAB

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

PRE-REQUISITES: High Voltage Engineering and Electrical Measurements at UG level.

COURSE DESCRIPTION:
To conduct experiments on Breakdown mechanisms in dielectrics materials; Generation & measurement of high DC, AC, impulse voltages and currents and testing high voltage electrical apparatus.

COURSE OUTCOMES: On successful completion of the course, student will be able to CO1. demonstrate knowledge on

- behavior of various insulationmaterials,
- generation of high voltage andcurrents,
- measuring techniques for high voltage andcurrents,
- testing of various electricalapparatus.

CO2. analyze the behavior of insulation systems, circuits for high voltage generation, measurement and testing.

CO3. evaluate various parameters of high voltage generating, measuring and testing circuits. CO4. initiate research to design a suitable setup for measuring and testing of High Voltage.

CO5. follow the IEC standards and safety measures for efficient operation and testing of high voltage equipment.

CO6. function effectively as an individual and as a member in a team

CO7. prepare laboratory report that clearly communicates the experimental information. CO8. practice professional code of ethics.

LIST OF EXPERIMENTS:
Conduct any **TEN** experiments from the following

1. Generation and characteristics of Lightning Impulse Voltages.
2. Generation of High DC voltage using voltage doublercircuit.
3. Spark over characteristics of gaseous, liquid and solid insulation under uniform and non- uniformfields.
4. Measurement of HVAC andHVDC.
5. Breakdown strength of transformer oil using oil-testingunit.
6. Determination of the Flashover Characteristics ofInsulators.
7. Determination of 50% Critical Impulse Flash-Over Voltages on the 11 kV type Insulator with Positive Impulse and NegativeImpulse.
8. Determination of String Efficiency of Suspension TypeInsulator.
9. Measurement of Capacitance and loss tangent.
10. Measurement of Earth and insulation resistance.
11. Partial discharge measurement in high voltageapparatus.
12. Calibration of meters by using Sphere Gap, Rod Gap and Point Gapmethod.

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 andPower 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

16MT10732: POWER SYSTEMS SIMULATION-I LAB

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

PRE-REQUISITES:

Power system operation and control, Power system analysis, Power quality, Power electronics and Control Systems at UG and PG level.

COURSE DESCRIPTION:
Modelling, simulation and analyze operation, control of power system Networks and Power electronics converters.

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

CO1. demonstrate knowledge on various problems in electrical engineering through modern tools and simulate the methods to mitigate using software packages in field of power system and powerelectronics.
CO2. analyze the simulated observations of power system networks, power electronic circuits and their behavior through theoretical perspective.
CO3. evaluate various parameters of the power systems/power electronic circuits
CO4. interpret the observations of network/circuits and design a suitable control strategy to meet the required specifications.
CO5. select and apply modern software tools for solving problems in the existing power system. CO6. function effectively as an individual and as a member in a team
CO7. prepare laboratory report that clearly communicates the experimental information.
CO8. practice the professional code of ethics.

LIST OF EXPERIMENTS:
Conduct any **TEN experiments** from the following using **MATLAB/ SIMULINK**

1. Formation of bus admittancematrix.
2. Formation of Bus Impedancematrix.
3. Load flow studies.
4. Contingencyanalysis.
5. Available Transfer Capabilitiescomputation.
6. Fault analysis using Bus impedancematrix.
7. Weighted Least Square linear and nonlinear stateestimation.
8. Analysis of various controller and observers for power systemapplications.
9. Three phase fully controlledRectifier.
10. Three phase inverter with PWMcontroller.
11. Buck and Boost converter for power system applications.
12. Resonant converter for power systemapplications.

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

(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. McNeils, 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
(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 andEnergy 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. Torstencegrell, *Power systems control Technology*, Prentice Hall, 1st edition, 1986.
2. Mini S Thomas and John D Mcdonald, *Power System SCADA and Smart Grids*, CRC Press, 1st edition, 2015.

3. M Shahidehpour, MuwaffaqAlomoush, *Restructured electrical power systems operation, trading and volatility*, CRC Press, 1st edition, 2001.

REFERENCE BOOKS:

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

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. McGranaghan, Surya Santoso and H. Wayne Beaty, *Electrical Power Systems Quality,* TATA McGraw Hill, 2^{nd} edition, 2008.

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 evaluatingthe 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 Billintonand Ronald N Allen, *Reliability Evaluation of Engineering Systems*, Springer, 2ndEdition,NewYork, 2013.
2. X. Wang & J.R. McDonald, *Modern Power System Planning* – McGraw Hill Book Company, 1994

M. Tech. I-Semester
16MT10708: POWER SYSTEM RELIABILITY
(Professional Elective - I)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	-	-	4

PRE-REQUISITES: Probability and Statistics at UG level

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

CO1. demonstrate knowledge on
- conceptual algorithms for planning, security and reliable operation of powersystem,
- system risks during normal and adverse weatherconditions.

CO2. analyze complex power system network structures for computation of reliability indices. CO3. evaluate the reliability of power system network using reliability indices.

CO4. initiate research in developing various algorithms for determining the power system network reliability for various operating scenarios.

DETAILED SYLLABUS:

UNIT – I: FUNDAMENTALS OFRELIABILITYENGINEERING (13Periods)

Probability Concept, Random variables, Probability Density and Distribution functions – Probability Distributions: time dependent and independent, Mean, SD, Variance. Reliability function, Hazard rate, types of Failures, Bath Tub Curve and Reliability cost and worth.

Network and Markov Modeling: redundant and non-redundant configuration – complex systems – conditional probability approach, Decomposition Method, cut-set, tie-set approaches – Standby redundant systems – Event trees. Markov chain – Markov Process, STPM, LSP – one, two and three component repairable models.

UNIT – II: EVALUATION OF GENERATINGCAPACITY RESERVE (10Periods)

Introduction – Generation system model – determination of capacity outage probability table – Identical units – Non-Identical units – Determination of transitional rates – deterministic and probabilistic criteria – Sequential addition method – Recursive relation for unit addition, unit removal - LOLP, LOLE, EIR.

UNIT – III: EVALUATION OF FREQUENCY AND DURATION TECHNIQUES (10 Periods)

Frequency and duration concepts – Two components repairable model (with & without identical components) – Evaluation of cumulative probability and cumulative frequency by using recursive relation – Equivalent transition rates – nonequivalent transition rates.

System risk indices: Daily load model – Two level representation of daily load modeling – evaluation of probabilities, transitional rates.

UNIT – IV: RELIABILITY ANALYSIS OFINTERCONNECTEDSYSTEM (12Periods)
Introduction – probability array method in two interconnected systems – evaluation techniques – equivalent assisting approach – factors affecting interconnections, effect of tie capacities, tie lines.
Weather effects on transmission lines – common mode failures – circuit breaker model – Preventive maintenance.

UNIT – V: DISTRIBUTION SYSTEMRELIABILITYANALYSIS (10 Periods)
Distribution system reliability system analysis – Basic indices – Customer oriented indices – Load and energy indices – Active and Passive failures – open circuit & short circuit failures – Problems.

Total Periods: 55

TEXT BOOKS:

1. Roy Billinton and Ronald N Allan, *Reliability Evaluation of Power Systems*, 2nd edition, Springer, New York,1996.
2. J. Endrenyi, *Reliability Modeling in Electric Power Systems*, 1st edition, A Wiley-Interscience Publication, John Willey and Sons, US,1979.

REFERENCE BOOKS:

1. Roy Billinton and Ronald N Allan, *Reliability Evaluation of Engineering Systems - Concepts and Techniques*, 2nd edition, Springer, New York, 2013.
2. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, Tata McGraw Hill, India,2004.

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
16MT20732: POWER SYSTEMS SIMULATION-II LAB

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

PRE-REQUISITES: Power system analysis, FACTS, Power system operation & control, Power quality and Switchgear and protection at UG and PG level.

COURSE DESCRIPTION: Modelling, simulation and analyze operation and control of power system networks.

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

CO1. demonstrate knowledge on various power system problems through modern tools and disseminate them using software packages in field of power system and power electronics.
CO2.analyze the simulated observations of power system networks, power electronic circuits and their behavior through theoretical perspective.
CO3. evaluate various parameters of the power systems
CO4. interpret the observations of power system network and design a suitable control strategy to meet the required specifications.
CO5. select and apply modern software tools for solving real time problems in the existing power system
CO6. function effectively as an individual and as a member in a team
CO7. prepare laboratory report that clearly communicates the experimental information.
CO8. practice professional code of ethics.

LIST OF EXPERIMENTS: Conduct any **TEN** Experiments from the following using MATLAB/PSCAD/MIPOWER

1. Transient Response due to capacitorswitching.
2. Transformer inrush currentsmeasurement.
3. Load flow analysis.
4. Analysis of Short circuit studies with and with faultimpedance.
5. Load frequency control problem for an interconnected powersystem.
6. Voltage stabilityanalysis.
7. Stability analysis ofSMIB.
8. Simulation of FACTScontrollers.
9. Characteristics and Coordination ofRelays.
10. Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)
11. Harmonic analysis and tuned filter design to mitigateharmonics.
12. Demonstration of MATLAB tool boxes (Fuzzy, Neural, GA, PSO etc.) for power system applications.

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
16MT20731: POWER SYSTEMS AND RELAYS LAB

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

PRE-REQUISITES: Electrical Machines and Power Systems at UG Level

COURSE DESCRIPTION: Relay testing, fault analysis, determination of sequence reactances of power system components, dielectric strength of transformer oil and synchronous machine power angle characteristics.

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

CO1. demonstrate knowledge in power system protection and testing of relays by combining existing and novel technology.

CO2. analyze protective schemes and testing methods in the field of power systems.

CO3. demonstrate skills in evaluating the power system network parameters and relay settings for appropriate protection.

CO4. initiate research to design/develop a suitable protection scheme for power system components/ networks.

CO5. apply modern numerical and processor based relays for protection and relaying.

CO6. function effectively as an individual and as a member in a team

CO7. prepare laboratory report that clearly communicates the experimental information.

CO8. practice professional code of ethics

LIST OF EXPERIMENTS: Conduct any **ten** Experiments from the following:

1. Determination of Sub-transient Reactance of Salient Pole SynchronousMachine.
2. Determination of Sequence Impedances of Cylindrical Rotor SynchronousMachine.
3. FaultAnalysis
   i) LG and LLFaults
   ii) LLG and LLLGFaults
4. Measurement of Dielectric Strength of Transformer Oil Using VariableElectrodes.
5. Reactive power compensation using Tap changingtransformer.
6. Power Angle Characteristic of Three-Phase Salient Pole SynchronousMachine.
7. Analysis of Long Transmissionline.
8. Determination of Sequence Components of Salient Pole SynchronousMachine.
9. Scott Connection ofTransformers.
10. Characteristics of Over CurrentRelay.
11. Characteristics of Over VoltageRelay.
12. Characteristics of Percentage Biased Differential Relay.
13. Testing of FrequencyRelay.
14. Testing of Reverse PowerRelay.

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, Multivariatedata - 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.
Prabhanjan N. Tattar, Suresh Ramaiah, B. G. Manjunath, *A Course in Statistics with R*, Wiley, 2018.