PG PROGRAM

DETAILED SYLLABUS

M.Tech

in

Power Systems Engineering

SCHEME OF INSTRUCTIONS FOR THE CURRICULUM & DETAILED SYLLABUS FOR POWER SYSTEMS ENGINEERING (MTECH-2019)

SEMESTER-I

S. No.	Course type	Course code	Course Title	Hrs/week		Internal marks	End Examination		Credits
				L	P		Duration	Marks	
1.	Program Core - I	19EEPS1001	Advanced Power System Analysis	3	0	40	3	60	3
2.	Program Core - II	19EEPS1002	Power System Dynamics	3	0	40	3	60	3
3.	Program Core - III	19EEPS1003	Modern Control Theory	3	0	40	3	60	3
4.	Program Elective - I	19EEPS1014	1. High Voltage testing techniques 2. Optimization Techniques in Power Systems 3. Advanced Digital Signal Processing Techniques	3	0	40	3	60	3
5.	Program Elective - II	19EEPS1015	1. Power Converters 2. Power Quality 3. Wind and Solar Systems	3	0	40	3	60	3
6.	Mandatory Learning Course	19EEPS1026	Research Methodology and IPR	2	0	40	3	60	-
7.	Laboratory-I	19EEPS1051	Power Systems Lab-I	0	3	40	3	60	1.5
8.	Laboratory-II	19EEPS1052	Computational Lab	0	3	40	3	60	1.5
			TOTAL	**17**	**6**	**320**	**--**	**480**	**18**

SEMESTER-II

S. No.	Course type	Course code	Course Title	Hrs/week		Internal marks	End Examination		Credits
				L	P		Duration	Marks	
1.	Program Core – IV	19EEPS2001	Advanced Power System Protection	3	0	40	3	60	3
2.	Program Core – V	19EEPS2002	Power System Operation & Control	3	0	40	3	60	3
3.	Program Core – VI	19EEPS2003	Flexible AC Transmission Systems	3	0	40	3	60	3
4.	Program Elective –III	19EEPS2014	1. HVDC Transmission 2. Digital Control Systems 3. Power Distribution Systems	3	0	40	3	60	3
5	Program Elective-IV	19EEPS2015	1. Deregulated Power System 2. Distributed Generation and Micro grid 3. Soft computing methods to Power Systems	3	0	40	3	60	3
6.	Audit Course	19EEPS2036	Technical Report Writing	2	0	40	3	60	-
7.	Term Paper	19EEPS2067	Term Paper/Seminar #	2	0	40	3	60	1
8.	Laboratory - I	19EEPS2051	Power Systems Lab-II	0	3	40	3	60	1.5
9.	Laboratory - II	19EEPS2052	Simulation Lab	0	3	40	3	60	1.5
			TOTAL	**19**	**6**	**360**	**--**	**540**	**19**

SCHEME OF INSTRUCTIONS FOR THE CURRICULUM & DETAILED SYLLABUS FOR POWER SYSTEMS ENGINEERING (MTECH-2019)

SEMESTER-III

S. No.	Course Type	Course Code	Course Title	Hrs/week		Internal marks	End Examination		Credits
				L	P		Duration	Marks	
1.	Program Elective –V (Self Learning Course)	19EEPS3011	To be approved by BOS	0	0	40	--	60	3
2	Project *	19EEPS3062	**Project Part-A**	0	20	40	-	60	10
3	Internship	19EEPS3051	Internship	0	0	-	-	-	2
			TOTAL	**0**	**20**	**80**	**-**	**120**	**15**

*To be continued in the IV Semester

SEMESTER-IV

S. No.	Course Type	Course Code	Course Title	Hrs/week		Internal marks	End Examination		Credits
				L	P		Duration	Marks	
1.	Project	19EEPS4061	**Project Part-B**	0	32	40	-	60	16
			TOTAL	**0**	**32**	**40**	**-**	**60**	**16**
			Grand TOTAL	**36**	**62**	**800**	**--**	**1200**	**68**

L – Lecture, P – Practical, C – Credits

19EEPS1001: ADVANCED POWER SYSTEM ANALYSIS

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: **Formulate** the incidence and network matrices using singular transformation and model the transmission lines and transformer.
CO2: **Perform** load flow analysis using Gauss-Seidel, Newton-Raphson, Fast decoupled and DC power flow methods.
CO3: **Formulate** bus impedance matrix using building algorithm and apply for short circuit studies.
CO4: **Analyze** the power system for contingency and state estimation.

UNIT-I

Incidence and Network Matrices: Introduction – graphs – incidence matrices formation - Y_{Bus}, Y_{BR} and Z_{loop} by singular transformation, single phase modeling of transmission lines, off-nominal transformer tap representation and phase shift representation - formation of Y_{bus} with direct inspection method.

UNIT-II

Power Flow Analysis: Formulation of power flow problem – solution through Gauss-Seidel method, Newton Raphson method - decoupled and fast decoupled power flow solutions - DC power flow solution – comparison of GS – NR – FDC method. Study of Power flow solution with FACTS devices - Renewable Energy Sources –Solar and Wind Energy Sources.

UNIT-III

Fault Studies: Algorithms for formation of Z_{bus} matrix; Short Circuit (SC) studies – introduction – Short circuit calculations using Z_{bus} – Z^f_{abc} – Y^f_{abc} – Z^f_{012} – Y^f_{012} matrices for various faults, Short circuit analysis using Z_{bus} for L–L–L, L-G, L-L and L-L–G faults. Analysis of open circuit faults- one line conductor open and two line conductor open.

UNIT-IV

Contingency Analysis: Adding and removing multiple lines, piece wise solution of interconnected systems, analysis of single and multiple contingencies, Contingency analysis by DC Model.

State Estimation: Method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

References:

[1] Stagg G.Ward, El–Abiad, Computer methods in power system analysis, McGraw Hill ISE.
[2] J.Arrilaga & C.P. Arnold: Computer Modeling of Electric Power Systems, John Wiley & Sons, N.Y.
[3] Nagarath & Kothari Modern power system analysis 3rd Edition, TMH.
[4] Nagsarkar & Sukhija, Power system analysis, Oxford press, New Delhi.
[5] Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' TMH, New Delhi.

19EEPS1002: POWER SYSTEM DYNAMICS

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Develop mathematical models of power system for dynamic studies.
CO2: Analyze small signal stability problems and understand methods of improving small signal stability.
CO3: Analyze transient stability problems and understand methods to improve it.
CO4: Analyze voltage stability problems and understand methods of improving voltage stability

UNIT-I

Synchronous Machine Modeling: Mathematical Description of a Synchronous Machine, Basic equations of a synchronous machine, dqo transformation, per unit representation, Stator and Rotor voltage and flux linkage equations, simplified model with amortisseurs neglected, constant flux linkage model, load modeling concepts, modeling of static excitation systems.

UNIT-II

Small Signal Stability: Basic Concepts of Dynamic Systems and Stability Definition, Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System, small signal stability of single machine infinite bus system, effect of field circuit dynamics, effect of excitation system, power system stabilizer, Analytical methods of calculating steady state stability limits, small signal stability of multi machine system, Methods of improving small signal stability.

UNIT-III

Transient Stability: An elementary view of transient stability, Swing equation, equal area criterion, solution of swing equation by numerical methods, Euler method, modified Euler's method and R-K methods. Methods of improving transient stability: High speed fault clearing, Reduction of transmission system reactance, regulated shunt compensation, Dynamic braking, Reactor switching, Single pole switching, Steam turbine fast valving, Generator tripping, controlled system separation and load shedding, High speed excitation systems, control of HVDC transmission links.

UNIT-IV

Voltage Stability Analysis: Voltage stability, voltage collapse and voltage security, Voltage stability of Single machine connected to infinite bus system, generation aspects, transmission system aspects, load aspects, PV curve, QV curve, analysis with static loads loadability limit, sensitivity analysis, continuation power flow analysis, instability mechanisms examples, methods of improving voltage stability.

References:

[1] Prabha Kundur, "Power system stability and control", Tata McGraw Hill
[2] Kimbark EW. "Power system stability-III, synchronous machines", John Wiley & Sons
[3] Taylor C.W. "Power systems voltage stability", TMH
[4] K.R. Padiyar, "Power systems Dynamics stability and control", Interline publishing pvt., ltd., Bangalore.

19EEPS1003: MODERN CONTROL THEORY

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Design a control system via pole assignment and observer using state feedback.
CO2: Perform the stability analysis of nonlinear systems using describing functions.
CO3: Analyze linear and non-linear systems using Lyapunov theorems and Design Lyapunov function for stable systems.
CO4: Formulate an optimal control problem and design optimal controller using Hamiltonian and/or LQR methods.

UNIT-I

State feedback controllers and observers: Controllability and Observability, State space representations of transfer-function systems –controllable, observable, diagonal (Jordan) canonical forms; State feedback controller design through Pole Assignment- Direct, Transformation Matrix, Ackermann's methods; State observers - Full order and reduced order - Direct, Transformation Matrix, Ackermann's methods

UNIT- II

Nonlinear Systems: Introduction –Properties of nonlinear systems - Types of Nonlinearities – Phase Plane - Singular Points – Classification – Introduction to linearization of nonlinear systems– Describing function–describing function analysis of nonlinear systems – Stability analysis of Non-linear systems using describing functions

UNIT-III

Lyapunov Stability Analysis: Equilibrium state, Stability in the sense of Lyapunov, Scalar functions-Sign definiteness, Lyapunov's stability and instability theorems - Stability analysis of the linear continuous- time invariant systems by Lyapunov second method– Direct method of Lyapunov – Generation of Lyapunov functions – Krasoviskii's and Variable gradient methods

UNIT- IV

Optimal Control: Introduction to optimal control - Formulation of optimal control problems – calculus of variations –Minimization of functions - Minimization of functional – functional involving independent functions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator

References:

[1] M.Gopal, "Modern Control System Theory", New Age International, 3/E
[2] Ogata.K, "Modern Control Engineering", PHI, 5/E
[3] M Gopal, "Control Systems – Principles and Design", TMH, 3/E
[4] IJ Nagrath and M Gopal, "Control System Engineering", New Age International -5/E
[5] Manjitha Srivastava et. al., "Control Systems", TMH

* Continuous-time systems only

19EEPS1014/1: HIGH VOLTAGE TESTING TECHNIQUES

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Understand the concept of Testing of different Insulators
CO2: Analyze high voltage testing techniques of Power apparatus and causes over voltages
CO3: Analyze non destructive testing of insulators
CO4: Understand the concept of high voltage measurement techniques

UNIT I

High Voltage Generators for Testing: Introduction –testing voltages; Generation of High direct voltages - A.C to D.C conversion, voltage doubler circuit, Cockcroft-walton voltage multiplier circuit, Electrostatic generators; generation of high alternating voltages – testing transformers, cascaded transformers, series resonant circuits, generation of high frequency alternating voltages using Tesla coil; Generation of high impulse voltages – Characteristics of Impulse Voltage, Single-stage Impulse Generator Circuits, Multi-stage Impulse Generator, tripping and control of impulse generators.

UNIT-II

High Voltage Testing of Power Apparatus: Need for testing standards – Standards for porcelain/Glass insulators-Classification of porcelain/glass insulator tests – Tests for cap and pin porcelain/Glass insulators.

Testing Techniques for Electrical Equipment: Testing of insulators-artificial pollution tests, bushings, air break switches, isolators, circuit breakers, power transformers, surge diverters, cable -testing methodology-recording of oscillograms - interpretation of test results.

UNIT-III

Non Destructive Testing Techniques: Measurement of DC Resistivity – Dielectric loss and dielectric constant of insulating materials – Schering bridge method – Transformer ratio arm bridge for high voltage and high current applications. Partial discharge measurements-basic partial discharge (PD) circuit – PD currents- PD quantities -Digital PD instruments and measurements, Corona and RIV measurements on line hardware.

UNIT-IV

High Voltage Measurements for Testing: Measurement of high alternating voltages – capacitor voltage divider, Capacitance voltage transformer; Measurement of high impulse voltages – Capacitance voltage divider, Delay cables; Measurement of peak voltages by using sphere gaps

References:

[1] Diter Kind, Kurt Feser, “High voltage test techniques”, SBA Electrical Engineering Series, New Delhi.
[2] Naidu M.S. and Kamaraju V., “High voltage Engineering”, TMH, New Delhi.
[3] Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd.
[4] Gallagher, T.J., and Pearmain A., “High Voltage Measurements, Testing and Design”, John Willey & Sons, New York.
[5] IS, IEC and IEEE standards for “Dielectric Testing of High Voltage Apparatus” W.Nelson, Applied Life Data Analysis, John Wiley and Sons, New York.
[6] IEC-60270, “HV Test technique - Partial Discharge Mechanism”, 3/e December 2000.

19EEPS1014/2: OPTIMIZATION TECHNIQUES IN POWER SYSTEM

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Formulate and solve LP Problem

CO2: Solve Nonlinear Programming Problems

CO3: Apply search methods to solve constrained and unconstrained optimization Problems.

CO4: Solve optimization problems using evolutionary techniques like Genetic Algorithms and Particle Swarm Optimization.

UNIT-I

Linear Programming: Introduction and formulation of models, Standard and canonical forms of LPP, assumptions in LPP, simplex method, simplex method using Artificial Variables, duality in L.P., dual simplex method, sensitivity analysis: change in coefficients of objective function.

UNIT-II

Non-linear Programming: Unconstrained problems of Maxima and Minima, Constrained problems of Maxima and Minima: Equality and inequality constraints, Lagrangian Method, Kuhn Tucker conditions.

Quadratic programming: Wolfe's Modified simplex method.

UNIT-III

Dynamic Programming: Solution of linear programming problem, simple problems.

One- dimensional search methods: Sequential search, Interval Halving Method, Fibonacci search.

Multi-dimensional search methods: Univariate search, gradient methods- steepest descent / ascent methods, conjugate gradient method: Fletcher – Reeves method, penalty function approach.

UNIT-IV

Evolutionary Optimization Techniques: Evolution in Nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm, Genetic Operators: Selection, Crossover and Mutation, Issues in GA implementation, anatomy of a particle-equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem.

References:

[1] S.S.Rao, "Engineering Optimization: Theory and Practice", 3rd Ed., New Age International.

[2] D. Sharma, "Operations Research12th edition", Kedar Nath Ram Nath & Co.

[3] Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", PHI

[4] Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland.

[5] Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons.

[6] Rajasekaran S, Pai, G.A. Vijaya Lakshmi., "Neural networks, Fuzzy logic and Genetic Algorihms: Synthesis and Applications", PHI.

19EEPS1014/3: ADVANCED DIGITAL SIGNAL PROCESSING TECHNIQUES

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to
CO1: **Understand** different discrete and their transformation techniques.
CO2: **Apply** DFT and FFT transformation techniques.
CO3: **Design** IIR Filters using different techniques.
CO4: **Design** FIR Filters using different techniques.

UNIT-I

Discrete Signals and Systems and Z transforms: Review of Discrete – Time Signal & System representation in Z–Transform domain – Inverse Z–Transform – Properties – System characterization in Z –domain - Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.

UNIT-II

DFT and FFT: Discrete Fourier Series, Properties of DFS, Discrete Fourier Transform, Properties of DFT, Linear convolution using DFT, Computations for evaluating DFT, Decimation in time FFT algorithms, Decimation in frequency FFT algorithm.

UNIT-III

IIR Filter Design Techniques: Introduction, Properties of IIR filters, IIR filter design using bilinear transformation and impulse Invariance methods; Design of Digital Butterworth and Chebyshev filters using bilinear transformation, Impulse invariance transformation methods. Design of digital filters using frequency transformation method.

UNIT-IV

FIR Filter Design Techniques and Multi-rate Signal Processing: FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects. Introduction to Multi-rate Signal Processing - Decimation - Interpolation – Introduction to STFT WT

Reference Books:

[1] Alan V Oppenheim and Ronald W Schafer, “Digital Signal Processing, Pearson Education”, PHI.
[2] Proakis, J. Gard and D. G. Manolakis, “Digital Signal Processing: Principals, Algorithms and applications”, 3rd ed., PHI.
[3] M.H.Hayes, “Digital Signal Processing”, TMH
[4] P.Ramesh Babu, “Digital Signal Processing”, 2nd ed., Scitech Publications.
[5] S K Mitra, “Digital Signal Processing: A Computer Based Approach”, 2nd ed., TMH.
[6] S.Salivahanan, “Digital Signal Processing”, TMH.

19EEPS1015/1: POWER CONVERTERS

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Illustrate and analyze the operation of various non isolated DC-DC converters.

CO2: Illustrate and analyze the operation of various isolated DC-DC converters.

CO3: Understand the operation of various multilevel inverters and apply various PWM techniques.

CO4: Demonstrate the operation of PWM rectifiers,

UNIT-I

Non Isolated DC-DC converters: Buck converter, boost converter, buck - boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design.

UNIT-II

Isolated DC-DC converters: Forward – fly – back - push-pull- and full-bridge converters. Relationship between I/P and O/P voltages- expression for filter inductor and capacitors.

UNIT-III

Inverters: Single phase, three phase, Multi-level inverters-diode clamped, flying capacitor, cascaded H-bridge.

Pulse Width Modulation Techniques: Single pulse, multi- pulse, sinusoidal PWM, space vector modulation.

UNIT-IV

Front End (AC-DC) converters: PWM rectifiers-configuration types, three-phase full and semi converters- reactive power- power factor improvements – extinction angle control- symmetrical angle control- PWM control

References:

[1] Mohammed H. Rashid, “Power electronics”, Pearson education, 3rd edition.

[2] Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronic Converters applications and Design”, John Wiley & sons, 3rd edition.

[3] Umanand L, “Power electronics essentials & applications”, Wiley India Pvt. Ltd.

[4] Robert. W.Erickson, “Fundamentals of Power electronics”, springer, 2nd edition.

19EEPS1015/2: POWER QUALITY

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: **Understand** and **assess** the severity of different power quality problems
CO2: **Analyze** voltage sag problems and suggest preventive techniques
CO3: **Understand** the fundamentals of harmonics and useful tools for harmonic assessment
CO4: **Assess** the effect of DG in power quality problems and know power quality monitoring

UNIT-I

Power Quality-an Overview: Power Quality definition, the power quality evaluation procedure, General classes of power quality problems: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation

Power acceptability curves: CBEMA, ITIC – Sources for Electric Power Quality problem in power system: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage

UNIT-II

Voltage sags and Interruptions: Sources of sags and Interruptions, Estimating Voltage sag performance-Area of vulnerability, equipment sensitivity to voltage sags, transmission system sag performance evaluation, utility distribution system sag performance evaluation.

Fundamental Principles of Protection: Solutions at the end-user level- Ferro-resonant transformers, Magnetic synthesizers, Active series compensators, Standby UPS, Hybrid UPS, Superconducting magnetic energy storage (SMES) devices-Evaluating the economics of different Ride-through Alternatives - Motor-Starting Sags -Dynamic Voltage Restorers for sag, swell and flicker problems

UNIT-III

Fundamentals of Harmonics: Harmonic distortion, Voltage vs Current distortion, Harmonics vs Transients, Power system Components under non sinusoidal conditions, Harmonic indexes, Harmonic sources from commercial loads, Harmonic sources from industrial loads, locating Harmonic sources, effects of Harmonic Distortion, Inter-harmonics.

Useful Tools for Harmonic Assessment: Introduction, Fourier series, Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform, Hartley Transform and Discrete Hartley Transform, Wavelet Transform.

UNIT-IV

Distributed Generation and Power Quality: Resurgence of DG, DG Technologies, Interface to the Utility System, Power Quality issues, operating conflicts

Power Quality Monitoring: Monitoring Consideration, Historical perspective of power quality measuring instruments, Power quality measurement equipment

References:

[1] Roger C. Dugan, MF Mc ranaghan, Surya Santoso and HW Beaty, "Electrical Power Systems Quality", TMH, 2/E
[2] Surajit Chattopadhyay, Madhuchhanda Mitra, Samarjit Sengupta, "Electric Power Quality", Springer
[3] Jos Arrillaga, Neville R. Watson, "Power System Harmonics", John Wiley & Sons.
[4] Math H.J.Bollen, "Understanding Power Quality Problems-Voltage sag & Interruptions", IEEE Press.
[5] Heydt G.T, "Electric Power Quality", Stars in a Circle Publications, 2nd edition.
[6] Angelo Baggini, "Handbook of Power Quality", Wiley

19EEPS1015/3: WIND AND SOLAR SYSTEMS

Lecture :	3 Hrs/ Week	**Internal Assessment:**	40
Credits :	3	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Understand wind systems and wind generation.
CO2: Apply power quality standards and regulations for the interconnection of wind farms.
CO3: Study and understand the Isolated Systems and Economic Aspects of Wind Power.
CO4: To impart knowledge in solar energy system through global, rigorous post graduate education.

UNIT-I

Historical development and current status: Introduction, Historical Background, Status of Wind Turbine Technology- Design approaches. Characteristics of Wind Power Generation, Basic Integration Issues Related to Wind Power.

Generators and Power Electronics for Wind Turbines: Introduction, State-of-the-art Technologies, Generator Concepts- Asynchronous (induction) generator, the synchronous generator, other types of generators.

Isolated systems with wind power: Use of wind energy in isolated power systems, categorization of systems and experience; wind power impact on power quality, interconnected system.

UNIT-II

Power Quality Standards for Wind Turbines: Introduction, Power Quality Characteristics of Wind Turbines, Impact on Voltage Quality.

Technical Regulations for the Interconnection of Wind Farms to the Power System: Introduction, Overview of Technical Regulations, Comparison of Technical Interconnection Regulations, Technical Solutions for New Interconnection Rules- Absolute power constraint, Balance control, Power rate limitation control approach, Delta control; Interconnection Practice.

UNIT-III

Introduction to solar energy and its prospects: Physical principles of the conversion of solar radiation into heat, flat-plate collectors, energy balance equation and collector efficiency, thermal analysis of flat-plate collector and useful heat gained by the fluid, concentrating collector, advantages and disadvantages of concentrating collector over flat-plate type collectors, solar energy storage systems, solar pond, applications of solar energy.

UNIT-IV

Photovoltaic Energy Conversion: Solar cells and their characteristics -PV arrays - Electrical storage with batteries - Switching devices for solar energy conversion Grid connection Issues - Principle of operation; line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing.

PV Applications: Stand alone inverters - Charge controllers - Water pumping, audio visual equipments, street lighting - analysis of PV systems

References:

[1] Thomas Ackermann, Editor, “Wind power in Power Systems”, JHS.
[2] G.D. Rai, “Non-conventional Energy Resources”, Khanna Publishers.
[3] Siegfried Heier, “Grid integration of wind energy conversion systems”, JWS.
[4] K. Sukhatme and S.P. Sukhatme, “Solar Energy”. TMH, Second Edition.
[5] B.H. Khan, “Non conventional Energy Resources”, TMH, 2nd edition.

19EEPS1026: RESEARCH METHODOLOGY AND IPR

Lecture :	2 Hrs/ Week	**Internal Assessment:**	40
Credits :	1	**Final Examination:**	60

Course Outcomes: After completion of this course the student should be able to

CO1: Acquire an overview of the research methodology and techniques to define research problem

CO2: Review the literature and identify the problem.

CO3: Analyze the optimum sampling techniques for collected data.

CO4: Apply various forms of the intellectual properties for research work.

UNIT-I

Research Methodology: Introduction, meaning of research, objectives of research, motivation in research, research approaches, significance of research, research and scientific methods, research process, criteria of good research, and problems encountered by researchers in India.

Research Problem: Defining the research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem, an illustration.

UNIT-II

Reviewing the literature: Place of the literature review in research, improving research methodology, broadening knowledge base in research area, enabling contextual findings.

Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design, basic principles of experimental designs, important experimental designs.

UNIT-III

Design of Sampling: Introduction, sample design, sampling and non-sampling errors, sample survey versus census survey,

Measurement and scaling: Qualitative and quantitative data, classifications of measurement scales, goodness of measurement scales, sources of error in measurement tools.

Data Collection: Experimental and surveys, collection of primary data, collection of secondary data, selection of appropriate method for data collection, case study method.

Testing of Hypotheses: Hypothesis, basic concepts, testing of hypothesis, test statistics and critical region, critical value and decision rule, procedure for hypothesis testing.

UNIT-IV

Interpretation and Report Writing: Meaning of interpretation, technique of interpretation, precaution in interpretation, and significance of report writing

Intellectual Property: The concept, Intellectual Property system in India, development of TRIPS complied regime in India, Patents Act 1970, Trade Mark Act 1999, The designs Act 2000, The geographical indications of Goods (Registration and Protection) Act1999, Copyright Act 1957, Trade secrets, Utility Models WTO, Paris convention for the protection of industrial property, national treatment, right of priority, common rules, patents, marks, Industrial designs, Trade names, indications of source, Unfair competition, patent cooperation treaty (PCT), Trade related aspects of Intellectual Property Rights(TRIPS) Agreement.

Text Books:

1. Research methodology: Methods and Techniques, **C.R. Kothari, GauravGarg,** New Age International, 4th Edition, 2018.
2. Research Methodology a step-by-step guide for beginners. **Ranjit Kumar, SAGE Publications** Ltd.,3rd Edition, 2011

3. Study Material, Professional Programme Intellectual Property Rights, Law and Practice, **The Institute of Company Secretaries of India**, Statutory Body under an Act of Parliament, September 2013.

References:

1. An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002
2. An Introduction to Multivariate Statistical Analysis Anderson T.W, Wiley 3rd Edition,
3. Research Methodology, Sinha, S.C, Dhiman, EssEss Publications2002
4. Research Methods: the concise knowledge base ,Trochim ,Atomic Dog Publishing ,2005
5. How to Write and Publish a Scientific Paper, Day R.A, Cambridge University Press 1992
6. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009
7. Proposal Writing, Coley S.M. Scheinberg, C.A, Sage Publications, 1990
8. Intellectual Property Rights in the Global Economy, Keith Eugene Maskus, Institute for International Economics.

19EEPS1051: POWER SYSTEMS LAB-I

Lecture :	--	**Practical:**	3Hrs/ Week	**Internal Assessment:**	40
Credits :	1.5			**Final Examination:**	60

Total a list of 12 experiments are given. Minimum of 8 experiments are to be conducted by the students.

List of experiments

1. Reactive power control by tap changing transformers
2. Measure sequence reactance's and fault studies on synchronous machine
3. Load compensation of power system network
4. Determination of sub-transient, transient, steady-state reactance of an alternator
5. Load flow study using AC network analyzer
6. Characteristics of microprocessors based relays
7. Characteristics of Static relays
8. High Voltage testing of insulators and cables
9. Measurement of Harmonics using power analyzer
10. Characteristics of PV Array
11. Effect of Temperature on Solar Panel Output
12. Effect of Load on Solar Panel Output

19EEPS1052: POWER SYSTEM COMPUTATION LAB

Lecture :	--	**Practical:**	3Hrs/ Week	**Internal Assessment:**	40
Credits :	1.5			**Final Examination:**	60

Total a list of 12 experiments are given. Minimum of 8 experiments are to be conducted by the students.

List of experiments

1. Develop program for Y_{bus} Matrix using Singular Transformation Method.
2. Develop program for Y_{bus} Matrix with Tap change Transformer using inspection method.
3. Develop program for Z_{bus} using building algorithm procedure.
4. Develop program for Performance of Transmission Line models.
5. Develop program for Gauss Seidel Load Flow Analysis.
6. Develop program for Newton Raphson Load Flow Analysis (Polar coordination).
7. Develop program for Fast Decoupled Load Flow Analysis.
8. Develop program for Short Circuit Analysis (LG, LLG and LLL Faults).
9. Develop program for security analysis and contingency ranking using load flow.
10. Develop the program to solve economic load dispatch problem without and with loss.
11. Develop program to study the effect of pole placement on system.
12. Develop program to convert the given transfer function into diagonal canonical form.