MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belgaum)

Autonomous Programmes

Bachelor of Engineering

DEPARTMENT OF

ELECTRICAL & ELECTRONICS ENGINEERING

SYLLABUS

VII and VIII Semesters

(4^{th} Year)

Academic Year 2022-23

VISION

To become a department of excellence in the domain of Electrical and Electronics Engineering producing competent engineers with research acumen having moral and social values.

MISSION

- Enhance industry and alumni interaction.
- Promote continuous quality up gradation of faculty and technical staff.
- Time to time modernization of departmental infrastructure to provide state of the art laboratories.
- Create research-oriented culture to invoke the desire and ability of lifelong learning among the students for pursuing successful career.
- Create and sustain environment of learning in which students acquire knowledge and learn to apply it professionally with due consideration of social and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the program will be able to

1. Design, analyse, operate and maintain equipment related to electrical and electronic industries with continuous integration with core and allied industries.
2. Use state of art laboratories and modern computer-based tools to pursue a diverse range of career as engineers and researchers.
3. Bring out innovations to provide best solutions to electrical engineering problems.
4. Fulfil the needs of society in solving technical problems using engineering principles, tools and practices, in an ethical and responsible manner.

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Develop models, design, analyze and assess the performance of different types of electrical machines, control systems and generation, transmission, distribution, protection mechanisms in power systems.

PSO2: Demonstrate knowledge and hands-on competence in the application of circuit analysis and design, associated software and applications, analog and digital electronics and microcontrollers to build, test, operate and maintain electrical and electronic systems

Scheme of Evaluation (Theory Courses)

Assessment	Marks
CIE 1	**15**
CIE 2	**10**
CIE 3	**15**
Activities (Quiz/Assignment/Mini Project/etc.) Minimum 2	**10**
SEE	**50**
Total	**100**

Scheme of Evaluation (Laboratory Courses)

Assessment	Marks
Continuous internal Evaluation in every lab session by the Course coordinator	**30**
Laboratory CIE conducted by the Course coordinator	**20**
SEE	**50**
Total	**100**

Examination	Maximum Marks	Minimum Marks to Qualify
CIE	**50**	**20**
SEE	**50**	**20**

Scheme & Syllabus for IV Year
Academic Year 2022 - 2023

VII Semester							
Course Category	**Course Code**	**Course Title**	L	T	P	**C**	**Contact Hrs.**
PCC-28	19EE701	Power System Operation & Control	3	1	0	**4**	5
PCC-29	19EE702	High Voltage Engineering	3	0	0	**3**	3
PCC-30	19EE703	Industrial Management & Engineering Economics	4	0	0	**4**	4
PCC-31	19EE704	Relay & High Voltage Lab	0	0	1	**1**	2
PCC-32	19EE705	Power System Simulation lab	0	0	1	**1**	2
PEC-3	19EE7XX	Elective – III	3	0	0	**3**	3
PEC-4	19EE7XX	Elective – IV	3	0	0	**3**	3
OEC-2	19OEXXXX	Open Elective - II	3	0	0	**3**	3
SEC-2	19SW72	SWAYAM Course-II (Mandate Audit Course)	-	-	-	**-**	-
PROJ	19PEE76	*Mini Project Work*	-	-	2	**2**	-
		Total Credits	**22**				**25**

Electives – III					
	Course Code	**Course Title**	**L-T-P**	**Credits**	**Contact hours**
	19EE731	HVDC Power Transmission	3-0-0	3	3
	19EE732	Electrical Power Quality	3-0-0	3	3
	19EE733	Discrete Control Systems	3-0-0	3	3
	19EE734	Overvoltage in Power Systems	3-0-0	3	3
	19EE735	Advanced Power Electronics	3-0-0	3	3
Electives – IV					
	19EE741	Industrial Drives and Applications	3-0-0	3	3
	19EE742	Insulation Engineering	3-0-0	3	3
	19EE743	Electromagnetic Compatibility	3-0-0	3	3
	19EE744	Flexible AC Transmission Systems	3-0-0	3	3
	19EE745	High Voltage Power Transformers	3-0-0	3	3
Open Electives - II					
	19OEEE71	Smart Grid Technologies	3-0-0	3	3
	19OEEE72	Utilization of Electric Power	3-0-0	3	3

VIII Semester						
Course Category	**Course Code**	**Course Title**	L	T	P	**C**
PC-33	19EE801	Internship	0	0	1	1
PC-34	19EE802	Seminar on Current Topic	0	0	1	1
PROJ	19PEE83	Project Work	0	0	9	9
PEC-5	19EE85X	Elective – V (Blended Mode)	3	0	0	3
PEC-6	19IEE8X	Industry Based Elective (Online)	2	0	0	1
		Total Credits	**15**			

Electives – V					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**#contact hours**
	19EE851	Solar Power Conversion Systems	3-0-0	3	3
	19EE852	Electric Vehicle Technology	3-0-0	3	3
	19EE853	Modern Power System Protection	3-0-0	3	3
	19EE854	Energy Auditing & Demand-Side Management	3-0-0	3	3
	19EE855	Embedded Systems	3-0-0	3	3
Industry Based Electives					
	19IEE81	Indian Electricity Acts and Implications	2-0-0	2	2
	19IEE82	Communication protocols in Power Systems	2-0-0	2	2
	19IEE83	Demand Forecasting using ML & AI	2-0-0	2	2

Course Title	Power System Operation and Control		
Course Code	19EE701	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective:

To create practical insight about Power System Operation and Control, hence study several intricate issues involved

Course outcomes: At the end of course, student will be able to:

#	Course outcomes	Mapping to PO's	Mapping to PSO's
1	Describe various aspects of electrical power system operation and system control strategies.	1	1
2	Analyze various intricate issues in respect of operating power systems and the different methods involved.	1,2	1
3	Solve various real life problems with respect to modern methods used in power system operation and control.	1,2	-
4	Elaborate on competence in handling various practical issues with respect to power system operation and control.	1,2	-

MODULE-1 **10 Hrs**

Introduction to Power system operation and control: Introduction, operating states of Power system, objectives of Power system control, key concepts of reliable operation, major threats to system security-case study.

Introduction to SCADA, components of SCADA system. Digital computer configuration. Introduction to voltage and reactive power control-production and absorption of reactive power, methods of voltage control by reactive power injection.

Self Study- *Indian power sectors.*

MODULE-2 **10 Hrs**

Automatic Generation control and interconnected Power systems:

Introduction, basic generator control loops, commonly used terms in AGC, functions of AGC, speed governors, mathematical model of ALFC, Automatic generation controller, proportional integral controller, Tie-line control with primary speed control, Tie-line bias control (frequency bias Tie-line control)

Self Study- *Practical implementation of AGC in India.*

MODULE-3 **10 Hrs**

Economic Operation of Power Systems: Introduction to Economic and Operational aspects of Power Systems, Optimal system operation with thermal plants, constraints in economic operation, Spinning reserve, Performance Curves, Incremental production costs for steam power plants, Problems of Economic Load Scheduling - solution through Equal Incremental cost criterion for operation of power plants, Equal Incremental cost criterion for operation of power plants with generation capacity limits and transmission losses considered, transmission loss as a function of plant generation, the B-coefficients, expression for incremental transmission loss in terms of B-coefficients, Numerical Examples comprising of all the cases included above.

Self study-- *: Algorithm for economic dispatch problem including losses*

MODULE-4 **10 Hrs**

Unit commitment: Introduction, Constraints in unit commitment, Priority list method, dynamic programming.

Power System reliability and security: Security levels system, reliability cost, adequacy indices, functions of system security, contingency analysis.

Self study*: Security of power system*

Text books:

1. Power System Operation and Control, Dr. K Uma Rao, Wiley India.

Reference Books:

1. George L. Kusic; Computer Aided Power System Analysis, PHI, New Delhi, II Edition Reprint, 2003. Calculus by Thomas Finney, 9th edition, Pearson education, 2002.
2. B.M. Weedy , B.J. Cory; Electric Power systems, John Wiley and sons, 4th edition.

Course Title	HIGH VOLTAGE ENGINEERING		
Course Code	19EE702	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to learn the technology associated in high voltage generation, measurement and testing..

Course outcomes: At the end of course, student will be able to:

#	Course outcomes	Mapping to PO's	Mapping to PSO's
1	Explain the classification, need to generate high voltages and applications of high voltages.	1	-
2	Demonstrate fundamental knowledge of gaseous insulation and theoretically analyze criterion for electrical breakdown of gaseous insulating media.	1,2	-
3	Describe the techniques of generating HVAC, HVDC, Lightning & Switching impulse voltage and current.	1,2	-
4	Explain measurement of high voltages, high currents and high voltage surges.	1,2	-

MODULE-1 **10 Hrs.**

Introduction: Introduction to HV technology, Advantages of electric power transmission at high voltages. Need for generating high voltages in a laboratory. Important applications of high voltages. Types of HV insulators, cables and bushings.

Breakdown phenomena: Classification of HV insulating media. Gaseous dielectrics: Ionization: Primary and secondary ionization processes. Criterion for gaseous insulation breakdown based on Townsend's theory. Limitations of Townsend theory, Streamer theory, Corona discharges. Breakdown in electronegative gases. Paschen's law and its significance. Time lags of breakdown.

MODULE-2 **10 Hrs.**

Generation of High voltage AC and DC: HVAC - HV transformer; Need for cascade connection and working of transformers units connected in cascade. Series resonant circuit - Principle of operation and advantages. Tesla coil. HVDC - Voltage doubler circuit. Cockcroft-Walton type high voltage DC set. Calculation of Voltage regulation, Ripple and Optimum number of stages for minimum voltage drop.

MODULE-3 **10 Hrs.**

Generation of Lightning Impulse voltages: Introduction to standard Lightning Impulse (LI) voltages and necessity of generating them in a laboratory. Analysis of single stage impulse generator – Deriving impulse voltage expression representing a double exponential wave.

Multistage IG and Generation of LI & SI voltages: Multistage impulse generator working on Marx principle. Rating of a Multistage impulse generator. Components of Multistage impulse generator.

Introduction to standard impulse currents and standard Switching Impulse (SI) voltages. Generation of Switching Impulse voltage - Various methods.

MODULE-4	10 Hrs.

Measurement of high voltages, currents and surges: Electrostatic voltmeter - Principle, construction and limitations. Chubb and Fortescue method for HVAC measurement. Generating voltmeter - Principle and construction.

Standard sphere gap for measurement of various types of high voltages; Factors affecting the measurements. Potential dividers - Resistance dividers, Capacitance divider, Mixed RC potential divider. Surge measurement - Klydanograph and magnetic links, Introduction to Partial discharges (PD), PD measurement.

Text Books:

1. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, 4th edition, Tata McGraw Hill, 1995.
2. C. L. Wadhwa, *High Voltage Engineering*, New Age International Private Limited, 1995.

Reference Books:

E. Kufell and W.S. Zaengl, *High Voltage Engineering Fundamentals*, 2nd Edition, Pergamon Press, 1984.

Course Title	Industrial Management and Professional Engineering practice		
Course Code	19EE703	L-T-P	(4-0-0) 4
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course Objective: The students will be able to acquire managerial skills from economic point and estimate electrical installation.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1	Interpret various functions of management and emerge as a productive member of society.	**1,12**	-
2	Assess familiarity on structure of the organization in present day scenario.	**1,12**	-
3	Discuss characteristics of Engineering Profession, Professional responsibility and Rules of Practice	**1,6**	-
4	Describe concepts of Project management and apply project management tools and techniques.	**1,11**	-

MODULE – 1	13 Hrs.

Introduction to Management: Managers and their work, Management Functions, Mintzberg's Managerial Roles and a Contemporary Model of Managing, Management Skills, Management history-Early, classical, behavioral, quantitative and contemporary approaches. Managers as decision makers: decision making process, types of decision making, decision making styles and effective decision making in today's world.

Self study- *: Strategic management.*

MODULE – 2	13 Hrs.

Functional areas of management: Planning-goals and plans, types of goals and plans, setting goals and developing plans. Organizing- Designing organizing structure, work specialization, departmentalization, span of control, centralization and decentralization. Controlling-the control process.

Motivation-Early and contemporary theories of motivation. Leadership-Early and contingency theories of leadership.

Self study-: *Green management and sustainability.*

MODULE -3	**13 Hrs.**

Professional Engineering Practice: Introduction, characteristics of a profession, The Engineering Profession, licence, professional responsibility, The Engineer's duty to report, Rules of Professional Engineering Practice, certificate of authorisation, advertising, Professional Standards.

Self study-: *Professional engineering bodies in India.*

MODULE -4	**13 Hrs.**

Project management: Introduction, Understanding Project Management, Defining Project Success, The Project Manager–Line Manager Interface, Defining the Project Manager's Role, Defining the functional Manager's Role, Defining the Functional Employee's Role, Defining the Executive's Role, The Downside of Project Management.

Time management and stress: Introduction, Understanding Time Management, Time Robbers, Time Management Forms, Effective Time Management, Stress and Burnout

Self study-: Effective Project Management in the Small Business Organization

Text Books:

1. **Management** by Stephen P Robinns, Prentice Hall
2. **Professional Engineering Practice:** Professional engineers Ontario, 101-40 Sheppard Avenue West Toronto ON M2N 6K9.

Reference Books:

1. PROJECT MANAGEMENT: A Systems Approach to Planning, Scheduling, and Controlling**.** Harold Kerzner.

Course Title	**Relay and High Voltage Laboratory**		
Course Code	**19EE704**	**L-T-P**	**(0-0-1) 1**
Exam	**3 Hrs.**	**Hours/Week**	**2**
SEE	**50 Marks**	**Total Hours**	**26**

Course Objective: Students will demonstrate practically the relay operating characteristics, Fuse characteristics and Sparkover (Breakdown) behaviour of air as an insulating medium, subjected to High voltage application.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Experimentally map field lines for co-axial cable model using electrolytic tank.	1,9,10	-
2	Conduct experiment on an Electromechanical type overcurrent relay, Static over-voltage relay, Static under-voltage relay, Microprocessor based over-current relay and Microprocessor based over-voltage/under-voltage relay to assess their operating characteristics.	1,9,10	-
3	Perform the experiment on given fuse wire sample to examine its fusing current versus melting time characteristic.	1,9,10	-
4	Conduct experiment for inferring sparkover behaviour of air insulation subjected for HVAC, HVDC applications under Uniform/Non-uniform field conditions.	1,9,10	-

5	Access the quality of transformer oil sample by conducting experiment as per standards and assessing dielectric strength of it.	1,9,10	-
6	Safely handle high voltage sources/units and prepare the effective report of experiments conducted.	1,9,10	-

1. Operating characteristics and calculation of error in operating time for over-current electromechanical relay.
2. Operating characteristics of static over-voltage relay and static under-voltage relay
3. Field mapping using electrolytic tank for cable model.
4. Current-time characteristics of fuse.
5. Operating characteristics of microprocessor based over-current relay.
6. Operating characteristics of microprocessor based over/under voltage relay.
7. Spark over characteristics of air insulation subjected to high voltage AC-with Sparkover voltage corrected to STP.
8. Spark over characteristics of air insulation subjected to high voltage DC under uniform field condition.
9. Spark over characteristics of air insulation subjected to high voltage DC under non-uniform field condition.
10. Generation of high voltage impulse.
11. Measurement of HVAC using standard spheres.
12. Breakdown strength of transformer oil, using oil testing unit.

Course Title	**Power System Simulation Laboratory**		
Course Code	**19EE705**	**L-T-P**	**(0-0-1) 1**
Exam	**3 Hrs.**	**Hours/Week**	**2**
SEE	**50 Marks**	**Total Hours**	**26**

Course Objective: Students will illustrate power system-based experiments using modern computer techniques

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Evolve strategies for optimal utilization of computer memory through sparsity oriented programming techniques.	1,2,3	2
2	Conduct program based experiments to simulate power system problems.	1,2	2
3	Use modern tools (C++/MATLAB / MiPower) to conduct power system based experiments.	1,2,5	2

MATLAB: MATLAB fundamentals, matrices, Vectors, matrix & array operations,Using built in functions, saving & loading data, script files- 3 Hours, Function files, language specific features much as loops, branches and control flow;

Power system simulation using, MATLAB, MiPower Software Package and C & C++

1. Y_{BUS} formation for power systems by the rule of inspection method (without mutual coupling).
2. Y_{BUS} formation for power systems without & with mutual coupling, by singular transformation method.
3. Formation of bus impedance matrix by using either rule of inspection or singular transformation methods.
4. ABCD parameters: Formation for symmetric configurations, verification of AD-BC=1 and determination of efficiency & regulation for short, medium and long transmission lines.
5. Determination of power angle diagrams for salient/non-salient pole synchronous m/cs, excitation emf & regulation.
6. To determine the swing curve for a Single machine infinite bus (SMIB) system.
7. To determine fault currents & voltages in power systems at a specified location for SLGF, DLGF, LLF and 3LG Fault, without and with fault impedance.
8. Load flow analysis of a given power system using Gauss Siedel method for at least 3 iterations for a 3 to 4 Bus system (Load flow data to be supplied).
9. To conduct load flow analysis using Newton Raphson method for at least 3 iterations for a 3 to 4 Bus system (Load flow data to be supplied).
10. Optimal generator scheduling for various power plants (max. four units) without and with the transmission losses.

Note: Expt. 1-6: Programme to be written and executed by the students. Expt. 7-10: Standard Package Programmes to be used for execution with reference to a given system data.

Reference Books:

1. Rudrapratap, *Getting started with MATLAB*, Oxford University press,
2. Bhave**,** *Object Oriented Programming with C++*, Pearson Education.

Elective III

Course Title	**HVDC Power Transmission**		
Course Code	**19EE731**	**L-T-P**	**(3-0-0) 3**
Exam	**3Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to theoretically analyze HVDC converter control, protection, MTDC operation and harmonic aspects.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1.	Discuss the advantages of HVDC transmission and types of HVDC links.	1	-
2.	Explain and analyze converter performance.	1	-
3.	Describe the techniques of converter control.	1	-
4.	Explain the principles of MTDC systems.	1	-

5.	Describe the protection of HVDC converters.	1	-
6.	Analyze various aspects of harmonics and harmonic filters.	1,2	-

MODULE-1	10 Hrs.

General aspects of DC transmission and comparison of it with AC transmission: Historical sketch, Types of DC links, Comparison of AC and DC transmission, Applications of DC transmission, Description of DC transmission systems.

MODULE-2	10 Hrs.

Converter circuits:Valve characteristics, Properties of converter circuits, assumptions, single phase and three phase converters.

Analysis of the bridge converter: Analysis with grid control without overlap, Analysis with grid control and overlap less than 60˚. Complete characteristics of rectifier, Inversion

MODULE-3	10 Hrs.

Control strategies: Basic means of control, Power reversal, Limitations of manual control, Constant voltage versus constant current control, Desired features of control, Actual control characteristics, Constant minimum ignition angle control, Constant current control, Stability of control, Tap changer control, Power control and current limits, MTDC systems.

MODULE-4	10 Hrs

Protection: General, DC reactors, Prevention of consequent commutation failures, Converter faults, DC Circuit breakers, Clearing line faults and re-energizing the line.

Harmonics and filter: Characteristic and Uncharacteristic harmonics, Telephone interference, Troubles caused by harmonics, Means of reducing harmonics, Harmonic filters

Text Books:

1. Prabha Kundur, *Power System Stability and Control*, Tata McGraw Hill, 9th Reprint, 2007.

Reference Books:

1. K. R. Padiyar, *HVDC Power Transmission Systems - Technology and System Interactions*, Wiley Eastern Limited, 1992.
2. E. W. Kimbark, *Direct Current Transmission - Volume I*, Wiley inter science, 1971.

Course Title	**Electrical Power Quality**		
Course Code	**19EE732**	**L-T-P**	**(3-0-0) 3**
Exam	**3Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: To interpret the power quality phenomenon and estimate the harmonics in Electrical Systems.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1.	Recognize the different terminologies of power quality.	1	-
2.	Interpret and evaluate the voltage sags and interruptions.	1	-
3.	Determine suitable solutions for transient over voltages.	1	-
4.	Appraise the fundamentals of harmonics.	1	-
5.	Develop solutions to minimize harmonic distortion.	1	-
6.	Assess power quality benchmark process and solve the issues of DG interfacing to utility.	1,2	-

MODULE-1	9 Hrs.
Introduction: Power quality-voltage quality, power quality evaluation procedures, general classes of power quality problems, Transients - long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuations, power quality terms.	
MODULE-2	**11 Hrs.**
Voltage sags and interruptions: Sources of sags and interruptions, Estimating voltage sag performance, fundamental principles of protection, Motor sags. **Transients over voltages:** Sources of transient over voltages, Principles of over voltages protection, Utility capacitor switching transients.	
MODULE-3	**10 Hrs.**
Fundamentals of harmonics: Harmonic distortion, harmonic indexes, harmonic sources from commercial loads, harmonic sources from Industrial loads, effects of harmonic distortion. **Applied harmonics:** Harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters**.**	
MODULE-4	**10 Hrs**
Power quality benchmark : Introduction, benchmark process, power quality contract, Power quality state estimation, including power quality in distribution planning, Interface to utility system, power quality issues, interconnection standards.	
Text Books: 1. Dugan, Roger C., Santoso, Surya, McGranaghan, Mark F/ Beaty and H. Wayne, *Electric Power Quality*, McGraw-Hill Professional Publication 2003.	
Reference Books: 1. G.T.Heydt, *Electric Power Quality*, Stars in a circle publications 1991. 2. M.H.Rashid, *Modern Power Electronics* Tata McGraw Hill 2002. 3. Math H. J. Bollen, *Understanding Power Quality Problems Voltage Sags and Interruptions* IEEE Press, 2000.	

Course Title	**Discrete Control Systems**		
Course Code	**19EE733**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective Students will be able to describe properties and application of insulation materials / systems and analyze insulation failure data for the life estimation.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Describe Z-plane analysis and convolution methods.	1,2	-
2	Formulate a discrete time system in state space model and will be able to find its solution.	1,2	1
3	Analyze the stability of digital control systems.	1,2	-
4	Successfully complete this course will have the ability to analyze digital control systems using time and frequency domain analysis.	1,2	2
5	Examine controllability and observability in discrete time domain.	1,2	2
6	Design digital controllers for various engineering applications.	1,2	-

MODULE-1	10 Hrs.
Z-Plane Analysis of Discrete-Time Control Systems: Impulse Sampling and data Hold, the pulse transfer function, Realization of digital controllers and digital filters.	
MODULE-2	**10 Hrs.**
Design of Discrete Time Control Systems by Convolution Methods: Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane, Transient and steady state response analysis design based on the root locus method, Design based on frequency response method, Analytical design method.	
MODULE-3	**10 Hrs.**
State Space Analysis: State space representation of discrete time systems, Solution of discrete time state space equations, Pulse transfer functions matrix, Discretization of continuous time state space equations.	
MODULE-4	**10 Hrs.**
Pole Placement & Observer Design: Controllability, Observability, Design via pole placement, State observers, and servo systems.	

Text Books:

1. Kutsuhiko Ogata,*Discrete-Time Control Systems,*2nd Edition, Pearson Education, 2003.

Reference Books:

1. Benjamin C. Kuo, *Digital Control System*, Oxford University Press; Second edition, 2012
2. M. Gopal, *Digital Control and State Variable Methods,* 2nd Edition, TMH, 2007.
3. Richard C. Dorf, Robert H. Bishop*, Modern Control System*, 11th Edition, Pearson Education, 2008.
4. John F. Dorsey,*Discrete Control Systems*, TMH

Course Title	**Overvoltage in Power Systems**		
Course Code	**19EE734**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: The students will analyse and asses the performance of power system against over voltages.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSOs
1	Understand various types and causes of over voltages in power system as per IEC 60071	1,6	-
2	Understand the methods of calculation of over voltages.	1	1
3	Understand the situation prone to cause the over voltages.	1	1
4	Understand the working and application of surge arresters, surge capacitors, controlled switching in reducing over voltages	1	1
5	Understand the insulation coordination in power system	1	1
6	Understand the practical reasons for over voltages and can suggest solutions for the over voltages problems in the real world situations	1	1

MODULE-1	12 Hrs.
Introduction to overvoltage's phenomena in power systems: Transient on transmission lines: Infinite line definition and its transient behaviour, finite line analyses, Analysis for different line terminations, problems. Bewely lattice diagram, problems	
MODULE-2	**12 Hrs.**
Use of transient network analyzer, Digital computers for solving large-scale problems, Characteristics of lightning discharges, Theory of cloud formation, Origin of lightning, Iso-keronic level, leader development, return stroke, various types of lightning interaction, back-flashover phenomena.	
MODULE-3	**8 Hrs.**
Shielding angle calculation for line, Grounding rods, Counter poise wire, problems, Origin and characteristics of switching overvoltages, problems of switching surges.	
MODULE-4	**8 Hrs.**
Behavior of apparatus & line insulation under all types of over voltages, concept of BIL, Protection of apparatus against over voltages, surge arresters, Insulation co-ordination	

Text Books:

1. Allan Greenwood, "Electrical Transients in Power systems" , 2nd edition, Wiley India, 2010.
2. R. S. Jha, A course in High Voltage Engineering, Dhanpat Rai and Sons, First edition, 1977

Reference Books:

1. M. S. Naidu and V. Kamaraju, High Voltage Engineering, 3rd edition, Tata McGraw Hill, 1995.
2. Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, Wiley Eastern Limited, 1987.Kenneth Rosen, Douglas Host, James Farber and Richard Rosinski, The Complete Reference UNIX, Tata McGraw-Hill, 2000 Edition.

Course Title	**Advanced Power Electronics**		
Course Code	**19EE735**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: The students will be able to design and analyze power converters/inverters.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Explain the working principle of various power electronic converters	1	-
2	Design dc-dc converters for various applications	1,2	-
3	Analyze the operation of inverters and its switching techniques.	1,2	-
4	Analyze the operation of switching dc power supplies.	1,2	

Module 1	10 Hrs
DC-DC SWITCHED MODE CONVERTERS: Introduction, Linear voltage regulators (LVRs), Basic Switching converter (SMPC), comparison between LVR & SMPC, Control of DC-DC Converters, Buck, Boost, Buck-Boost, and Cuk converters (CCM, Boundary condition, DCM, Ripple, Applications, Merits and Demerits), DC-DC Converter comparison, Problems	

Module 2	10 Hrs
DC-AC SWITCHED MODE INVERTERS: Introduction, Basic Concepts of Switch-Mode Inverters,Single-phase Half Bridge, Single-phase Full Bridge, Push-Pull Inverters, Switch Utilization in Single Phase Inverters. Current Source Inverters, Variable DC-link Inverter, Inverter Circuit Design	
Module 3	**10 Hrs**
RESONANT CONVERTERS: Introduction, Switch-mode Inductive Current Switching, Classification of Resonant Converters, Resonant switch converters (ZCS, ZVS and comparison), Zero voltage switching – Clamped Voltage (ZVS-CV DC-DC Converters). Resonant DC Link Inverters with Zero voltage switchings	
Module 4	**10 Hrs**
Introduction, DC-DC Converters with Electrical Isolation, Fly-Back converter, Forward converter, Push-Pull converter, Half Bridge converter, Full Bridge converter, Power Conditioners and Uninterruptible Power Supplies	
Text books: Mohan N, Undeland T.M., Robins, W.P,John Wiley ,3rd Edition 2008, Power Electronics - converters, application & design.	
Reference books: 1. Daniel.W.Hart, TMH, First Edition, 2010, Power Electronics. 2. Rashid M.H., PHI, 3rd Edition, 2008, Power Electronics-Circuits, Devices, Applications.	

Course Title	**Industrial Drives and Applications**		
Course Code	**19EE741**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students shall analyze the working of various electrical machines fed from power converters

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Identify various electric drives systems and their role in specific applications related to torque, speed and position.	1, 2	1
2	Examine the operation of DC motor drives.	1	-
3	Investigate different techniques, skills and modern engineering tools for controlling dc motor drives.	1,2, 5	-
4	Analyze the operation of Induction/synchronous motor drives during Unbalance/Starting and Braking conditions.	1, 2	-
5	Adopt different power electronic converters for controlling Induction/synchronous motor drives.	1, 2	1
6	Analyse the operation of various electric motor drives in industries.	1	-

Module 1	12 Hrs
An Introduction to Electrical Drives and Its Dynamics: Electrical drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, status of AC&DC drives, fundamental torque	

equation, speed torque conventions and Multiquadrant operation, equivalent value of drive parameters, components of load torques, nature & classification of load torques, load equalization.

Module 2	**10 Hrs**

DC Motor Drives: Introduction to DC motors, starting, braking, Transient Analysis-(a) Transient analysis of separately excited motor with armature control (b) Transient analysis of separately excited motor with field control., **Controlled Rectifier Fed DC drives**-(a) Single phase fully controlled rectifier control of DC separately excited motor (b) Single phase half-controlled rectifier control of DC separately excited motor (c) Dual converter control of DC separately excited motor (d) Control of fractional HP motors

Module 3	**10 Hrs**

Induction Motor Drives: Introduction to IM, Operation with unbalanced source voltages and single phasing, operation with unbalanced rotor impedances, starting, braking, variable frequency control from voltage sources, Voltage source inverter control, slip power recovery, linear induction motor and its control.

Module 4	**8 Hrs**

Synchronous Motor Drives: Introduction to synchronous motors, Operation from fixed frequency supply synchronous motor variable speed drives, Sinusoidal PMAC Motor drives

Text books:

.K.Dubey, *Fundamentals of electric drives*, 2nd Edition, Naroso Publishing House, 5th Reprint, Chennai-2002

Reference books:

1. N.K.De & P.K.Sen, *Electrical Drives*, PHI-2007.
2. S.K. Pillai, *A First Course on Electric Drives*, Wiley Eastern Ltd.

Course Title	**Insulation Engineering**		
Course Code	**19EE742**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to describe properties and application of insulation materials / analyse insulation failure data for the life estimation

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Discuss the physics of dielectric phenomena.	1	-
2	Compare Insulation systems for various power apparatus.	1	-
3	Distinguish properties of natural and synthetic insulating materials.	1	-
4	Describe properties and electrical breakdown processes of gaseous insulation.	1	-
5	Compare ageing mechanisms of high voltage insulating materials.	1	-
6	Analyse insulation failure data for life estimation of insulation.	1	-

Module 1	**10 Hrs**

Insulation system in power apparatus: Insulation system in capacitors, bushings, transformers, Modes of failure of insulation systems. Insulation in rotating machines

Dielectric phenomena: Dielectric phenomena in solid insulation. Macroscopic approach for describing the dielectric phenomena: Microscopic treatment for dielectric phenomena

Module 2	**10 Hrs**

Properties of insulation materials: Introduction to properties of solid insulating materials (both of natural origin and synthetic types). Properties of liquid insulating materials, Review of breakdown phenomena in solid and liquid insulating media

Module 3	**10 Hrs**

Gaseous insulation: Requirement of gaseous insulation. Breakdown processes: Types of collision, Elastic and inelastic collisions, Collision cross-section, Mobility of ions, Diffusion of charges, Emission of radiation and excitation, various secondary processes and recombination, Mobility controlled and Diffusion controlled breakdown.

Module 4	**10 Hrs**

Ageing phenomena: Failure of electrical insulation due to ageing. Ageing mechanisms-Thermal ageing, Electrical ageing, combined thermal and electrical ageing

Text books:

T. S. Ramu and Chakradhar Reddy, *Reliability and Life Estimation of Power Equipment*, 1st Edition, New Age International, 2009

Reference books:

1. Bradwell A., *Electrical insulation*, Peter Peregrinus Ltd., London, 1983.
2. Nasser E., *Fundamentals of Gaseous Ionization and Plasma Electronics*, John Wiley Interscience, New York, 1971.
3. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, 3rd edition, Tata McGraw Hill, 1995.

Course Title	**Electromagnetic Compatibility**		
Course Code	**19EE743**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to analyse issues of electromagnetic compatibility in electrical and electronic devices.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Gain the basic knowledge of origin of EMI, types of EMI and the methods of eliminating EMI.	1	-
2	Learn how cable must be shielded to eliminate noise coupled due to electrostatic and magnetic field.	1	-
3	Get knowledge of different types of grounding that is in practice.	1	-
4	Gain knowledge of effective way of grounding cable shield to mitigate the problems of noise from ground signals.	1	-
5	Learn how shielding reduces absorption loss and reflection loss when the electromagnetic signals pass through it.	1	-

6	Learn the different materials available for effective shielding against electromagnetic radiation.	1	-

Module 1	10 Hrs
Definition of EMI, EMC, origin of interference, Designing for Electromagnetic compatibility, EMC regulation, Typical Noise path, use of network theory. Method of noise coupling, miscellaneous noise sources, Methods of eliminating interference	
Module 2	**10 Hrs**
Cabling: Capacitive coupling, Effect of shield on capacitive coupling, Inductive coupling, mutual inductance calculations, Effect of shield on magnetic coupling, Magnetic coupling between shield and inner conductor. Shielding to prevent magnetic radiation, shielding a receptor against magnetic fields, shied transfer impedance Experimental data, Example of Selective shielding, coaxial cable versus shielded twisted pair braided shields.	
Module 3	**10 Hrs**
Grounding: Safety grounds, signal grounds, single point ground systems hybrid grounds, multipoint ground systems, functional ground layout, practical low frequency grounding, hardware grounds, single ground reference for a circuit amplifiers shields. Grounding of cable shields, ground loops, low frequency analysis of common mode choke, high frequency analysis of common mode choke, differential amplifiers	
Module 4	**10 Hrs**
Shielding: Near fields and far fields, characteristic & wave impedance's shielding effectiveness, absorption loss, reflection loss, composite adsorption & reflection loss, summary of shielding equation. Shielding with magnetic material, experimental data, apertures, wave guide below cut off, conductive gaskets, conductive windows, conductive coatings, cavity resonance, brooding of shields.	
Text books: Henry W. Ott, "Noise Reduction Techniques in Electronic Systems", Second Edition, John Wily & Sons, 1989.	

Course Title	**Flexible AC Transmission Systems (FACTS)**		
Course Code	**19EE744**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students are able to understand importance of FACTS controller in transmission system.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Understand the basic knowledge of FACTS controllers in the power system.	1	-
2	Explain the concept of different FACTS controllers such as SVC, STATCOM, TCSC, GCSC, TSSC, SSSC etc.	1,2,3	-
3	Apply and analyze different types of shunt FACTS controllers such as SVC, STATCOM to improve the performance of the transmission line.	1,2,3	-

4	Apply and analyze different types of series FACTS controllers such as TCSC, GCSC, TSSC, SSSC, voltage regulators, PAR, UPFC, IPFC to improve the performance of the transmission line.	1,2,3	-

Module 1	**10 Hrs**

FACTS Concepts & General System Considerations: Flow of power in an AC system, limits of the loading capability, Power flow and dynamic stability considerations of a transmission interconnection, relative importance of controllable parameters, Basic types of FACTS controllers, Benefits from FACTS.

Voltage Sourced Converters: Basic concept, Single-phase full-wave bridge converter operation, Single phase-leg operation, voltage harmonics for a single-phase bridge, three phase full wave bridge converter, sequence of valve conduction process in each phase-leg.

Module 2	**10 Hrs**

Static Var Compensator (SVC): Objective of shunt compensation, Types of shunt compensators- **i) Variable Impedance type, ii) Switching converter type, iii) Hybrid Var generators;** Types and operating principles of SVC - TCR, TSR,TSC, FC-TCR, TSC-TCR; V-I characteristic of SVCs, Voltage control of TCR.

STATCOM : The regulation slope, Var reserve control , Comparison between SVC and STATCOM, The Principle of STATCOM Operation with and without energy system, The V-I Characteristic of STATCOM.

Module 3	**10 Hrs**

Static Series Compensators- TCSC, GCSC, TSSC: Objectives of series compensation, Fixed-Series Compensation, Variable impedance type of series compensators, The Thyristor-Controlled Series Capacitor (TCSC), Advantages of the TCSC, The TCSC Controller, Basic Operation of the TCSC, Modes of TCSC Operation – Bypassed Thyristor Mode, Blocked Thyristor Mode, Partially Conducting Thyristor, or Vernier Mode; V-I characteristic of TCSC, Basic operation of GCSC and TSSC, V-I characteristics of GCSC and TSSC.

Switching converter type series compensators-SSSC: Objectives of switching converter type series compensators, Power transmitted by SSSC, transmitted power versus transmission angle characteristic, principle operation of SSSC with and without energy system

Module 4	**10 Hrs**

Static Voltage and phase angle regulators: Objectives of Voltage and Phase Angle Regulation, Power Flow Control by Phase Angle Regulators, Real and Reactive Loop Power Flow Control.

Approaches to Thyristor-Controlled Voltage and phase Angle Regulators (TCVRs and TCPARs), Continuously Controllable Thyristor Tap Changers- with resistive load, Thyistor Tap Changer with Discrete Level Control – with identical winding.

Unified Power Flow Controller –UPFC: Introduction to Unified Power Flow Controller, Basic Operating Principles, Conventional Transmission Control. The Interline Power Flow Controller (IPFC), Basic Operating Principles

Text books:

Narain G. Hingorani and Laszlo Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, Standard Publishers Distributors, Delhi, First Edition, 2001

Reference books:

1. R. R. Mohan Mathur and Rajiv K. Varma, THYRISTOR-BASED FACTS CONTROLLERS FOR ELECTRICAL TRANSMISSION SYSTEMS, IEEE Press, John Wiley and Sons, First Edition, 2002.
2. K. R. Padiyar, FACTS, Controllers in Power Transmission and Distribution, New Age International Publishers, First Edition, 2007

Course Title	High Voltage Power Transformer		
Course Code	19EE745	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to formulate theoretical techniques of assessing the behaviour of high voltage power transformers

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Understand equivalent circuit and methods of separating the leakage reactance of a high voltage power transformer.	1	-
2	Explain theoretical derivations of Leakage reactance expressions for various MMF distributions pertaining to different types (based on winding configurations) of high voltage transformers.	1,2	-
3	Analyze electromagnetic forces arising due to short circuit, Magnetizing inrush current phenomena, OLTC gears and their operational comparisons.	1	-
4	Perform surge behaviour analysis of a transformer for its Initial voltage distribution, Voltage gradient & Effective capacitance calculation and Frequency dependent behaviour (based on principles of Travelling wave and Standing wave theories).	1	-

Module 1	11 Hrs

Power transformer: Difference between ordinary transformer and power transformer, Concept of leakage flux and leakage reactance, Equivalent circuit, Significance and role of equivalent circuit elements, Limitations and validity of equivalent circuit, Separation of leakage reactance by (i) Voltage drop due to no-load current (ii) Series opposition test. Separation of leakage impedance in a 3-phase transformer with Y-Δ connection

Magnetic leakage and reactance calculation: Reactance calculation in two-winding transformer – Rogowskii's equivalent, Leakage inductance calculation for Interleaved coils case, Three-winding transformers equivalent circuit, Experimental determination of equivalent circuit parameters, Relating them to equivalent Two-winding transformer parameters, Arbitrary MMF distribution, Scott connection, Zig-zag coils and Coils of unequal height cases

Module 2	10 Hrs

Electromagnetic forces on short circuit: Philosophy; Evaluation of radial and tensile forces; Hoop tension and copper loss; Axial force calculation, Volts per turn and Concept of AT thinning.

Magnetizing current inrush phenomena: Estimation of magnitude of inrush current and its maximum value. Inrush current in 3-phase transformers; Eddy current loss in conductors placed in an alternating magnetic field; its evaluation and minimization in transformer

Module 3	9 Hrs

On-load Tap Changing (OLTC) in a transformer; Reactor type – buffer reactor symmetrical and asymmetrical types; OLTC with single untapped reactor; Resistor type of OLTC; Comparison of reactor and resistor cycles

Surge phenomena in transformers: Equivalent circuit – Initial voltage distribution with grounded and insulated neutral; Voltage gradient – Line end stress; Effective capacitance evaluation.

Module 4	10 Hrs

Traveling Wave Theory: Role of inductance, Definition and origin of travelling waves, Frequency behavior of velocity of propagation – Equivalent circuits – Fourier spectrum of unit step wave.
Standing Wave Theory: Role of mutual inductance, Definition and origin of standing waves; Analysis for earthed neutral and insulated neutral cases; Insulation requirement of transformers against surges – Principle of fully shielded transformers and interleaved disc coils.

Text books:

S. B. Vasutinsky, Principles, *Operation and Design of Power Transformers, PSG College of Technology*, Coimbatore, 1962

Reference books:

1. L.F. Blume, A. Boyajian, G. Camilli, T.C. Lennox, S. Minneci and V.M. Montsinger, *Transformer Engineering*, 2nd edition, John Wiley and Sons Inc., New York, Chapmann and Hall limited, London, 1951.
2. BHEL (Bhopal), *Transformers*, Tata McGraw-Hill Publishing Company Limited, 1990.

OPEN ELECTIVES

Course Title	Smart Grid Technologies		
Course Code	19OEEE71	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: To create the practical insight about the modernization of Electrical Power System and hence study several issues involved in realization of Smart Grid

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Interpret different components of smart grid	1	-
2	Identify various avenues of Smart grid in context to real time power system operations.	1	1
3	Explain and analyse operational features of Smart grid.	1	-
4	Assess role of Smart grid to address real life challenges in power system operation and control	1,6	-

Module 1	10 Hrs

Introduction to Smart Grid

Evolution of Electric Grid, Evolution of Indian National Grid, Regulatory authorities in Indian Power sector, Concept of Smart Grid, Why implement the Smart Grid now?, Early Smart Grid initiatives, Overview of the technologies required for the Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid.

Information and communication technologies: Data communication- Introduction, switching techniques and communication channels. Layered architecture and protocols-ISO/OSI model and TCP/IP

Self study:- *Smart grid initiatives in India*

Module 2	**10 Hrs**

Smart Grid Enabling Technologies: Smart metering: Key components of smart metering, overview of the hardware used, Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication. *Communications infrastructure:* Home-area network, Neighborhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations

Self study:- Cyber Security for Smart Grid

Module 3	**10 Hrs**

Smart Measurement and Monitoring Technologies: Smart Substations, Substation Automation equipment's, Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Wide Area Measurement System (WAMS), Phasor Measurement Unit(PMU).

Self study:- *Computational tools to Smart Grid*

Module 4	**10 Hrs**

Renewable Energy and Storage: Renewable Energy Resources, Sustainable Energy Options for the Smart Grid, Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids. Storage Technologies: introduction, various energy storage technologies. Case study- Agent based control of EV battery charging

Self study:- *Microgrid and renewable energy.*

Text books:

Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", wiley India.

Reference books:

James Momoh "*SMART GRID Fundamentals of Design and Analysis*", IEEE press, A John Wiley & Sons, Inc., Publication

Course Title	**UTILIZATION OF ELECTRICAL POWER**		
Course Code	**19OEEE72**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to learn the technology associated in electric power utilization

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Introduce various electric drives and their applications	1	-
2	Discuss different methods of electrical heating and electric welding.	1	-
3	Explain various techniques for designing indoor &outdoor lighting schemes	1	-
4	Discuss the fundamentals electric traction	1	-

Module 1	**10 Hrs**

ELECTRIC HEATING AND WELDING:

Advantages and methods of electric heating, resistance heating induction heating and dielectric heating. Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding

Module 2	**10 Hrs**

ILLUMINATION FUNDAMENTALS AND ILLUMINATION METHODS:

Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere, sources of light. Discharge lamps, MV and SV lamps – comparison between tungsten filament lamps and fluorescent tubes, Basic principles of light control, Types and design of lighting and flood lighting.

Module 3	**10 Hrs**

ELECTRIC DRIVES: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, particular applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization.

Module 4	**10 Hrs**

ELECTRIC TRACTION: System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking-plugging rheostatic braking and regenerative braking.

Text books:

1. E. Openshaw Taylor, Utilization of electrical energy, Orient Blackswan
2. VedamSubrahmanyam, Electrical Drives: Concept and applications, THM.

Reference books:

H.Pratab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Co.

Course Title	Internship		
Course Code	19EE801	L-T-P	(0-0-2) 2
Exam	-	Hours/Week	5
SEE	-	Total Hours	20

COURSE OBJECTIVE: To expose students to organizational work culture in an industry/corporation.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the organization structure and hierarchy in an industry.	6,9,10	-
2	Discuss the organizational workflow in the industry demonstrating aspects on professional ethics.	6,8,9,10	-
3	Describe the analysing and problem solving skills acquired in the industry.	6,9,10	-

Course Title	Seminar on Current Topic		
Course Code	19EE802	L-T-P	(0-0-2) 2
Exam	-	Hours/Week	--
SEE	50 Marks	Total Hours	--

COURSE OBJECTIVE: To expose students to the real world working environment and to promote and imbibe presentation and communication skills

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Develop technical documents related to the work carried out, good communication skills and teamwork.	1,10	-
2	Identify appropriate sources that can be summarized and integrated into oral presentation using multimedia tools.	1,10	-
3	Be aware of importance of access to data, knowledge and results of engineering studies.	1,10	-
4	Be aware of importance and role of honesty, ethics, intellectual property rights and rules of access to data and technical information.	1,8,10	

Course Title	Project work		
Course Code	19PEE83	L-T-P	(0-0-9)9
Exam	3	Hours/Week	--
SEE	50 Marks	Total Hours	--

COURSE OBJECTIVE: To provide students an opportunity to exercise their creative and innovative qualities in a group project environment and to excite the imagination of aspiring engineers, innovators and entrepreneurs

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Demonstrate a sound technical knowledge of the selected project topic and develop teamwork skill.	1,9	-
2	Demonstrate the knowledge, skills and attitudes of a professional engineer in problem identification, formulation and solution.	1,2,3,6	-
3	Design engineering solutions to complex problems utilizing a systems approach.	1,3,4	-
4	Formulate engineering project and develop written and oral communication skills.	1,10	-
5	Understand professional ethics and responsibilities and norms of the engineering practice.	6,8	-

Elective V

Course Title	Solar Power Conversion Systems		
Course Code	19EE851	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to analyse and design solar power conversion system for real time applications

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	To gain the basic knowledge about structure of solar PV cells, connection diagrams of modules and array for real time applications.	1	-
2	To design & costing of solar thermal systems such as solar water heater, cooker for rural community sectors and performance analysis of solar collectors	1,2,6	-
3	To analyze and sizing of solar modules, battery and inverter systems for standalone applications.	1,2,6	-
4	To gain the knowledge about real time cost estimation for solar energy system.	1,2,6	-

Module 1	10 Hrs
Basic of Solar PV Cells: Structure of solar cell, types of solar cell, equivalent circuit of a PV cell, I-V and P-V characteristics solar cell, solar cell efficiency, fill factor, Effects of temperature, irradiance, series and shunt resistance on characteristics of solar cell. **Solar Photovoltaic Modules:** Solar PV modules & arrays from solar cells - Series and parallel connection of modules, mismatch in cell/module. Mismatch in series connection - Hot spots in the module & bypass diode, mismatching in parallel connection - blocking Diode.	
Module 2	**10 Hrs**
Solar Thermal Systems Design & Applications: Solar thermal systems-concentrating & non- concentrating types of collectors with examples. Liquid Flat plate collectors –working principle, Performance analysis, Energy gain and thermal efficiency, numerical examples. **Applications –** Solar water heater-working principle, types of heating system, components &specifications, design & costing of solar water heater. Solar cooking systems-Box type & dish type, Space heating systems, solar cookers-materials used, payback period calculations. Solar based power generation.	
Module 3	**10 Hrs**
Photovoltaic Systems Design & Applications: Basic components of SPV system, stand-alone PV system configurations. Design methodology of PV systems-PV –powered DC Fan without battery system, PV powered DC pump. Design of stand-alone PV system with battery & inverter for AC - DC load- Design of sizing of PV module, inverter, Battery bank for a given AC load and numerical examples. Hybrid PV systems- , types of hybrid systems, issues with hybrid system. Grid connected PV systems –two stage grid connected systems.	
Module 4	**10 Hrs**
Economic analysis: Lifecycle costing (LCC), time value of money**,** present worth of future one –time investments, present worth of future worth of future recurring investments, Life cycle cost, Annualized LCC (ALCC), unit cost of generation and numerical examples. Initial and annual costs, definitions, Repayment of loan in equal annual installments costs, Annual solar savings, Cumulative solar saving (CSS) and lifecycle savings, ADD-ON solar systems, payback period and numerical examples	
Text books: 1. Chetan Singh Solanki, Solar Photovoltaic - Fundamentals, Technologies and Applications. 3rd edition, PHI Learning Pvt. Ltd.VedamSubrahmanyam, Electrical Drives: Concept and applications, THM. 2. S.P.Sukhatme, Solar Energy: Principles of thermal collection and storage. McGraw-Hill Education, 1996.	
Reference books: 1. Chenming Hu,R. M. White, Solar cells-From Basic to Advanced Systems, McGraw-Hill, 1983. 2. G.D. Rai, Non-conventional Energy Sources	

Course Title	**Electric Vehicle Technology**		
Course Code	**19EE852**	**L-T-P**	**(3-0-0)3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**
Course objective: To enlighten students with various aspects of Electric Vehicles and Hybrid Electric Vehicles so that they will be able to compare and analyse different configurations in electric drive train, different types of electrical machines and their control, various options of energy storage etc.			

Course outcomes: The student will be able to

#	Course Outcomes	Mapping to POS	Mapping to PSO's
1	Recognise and recall the history, necessity, and evolution of different type of electric vehicles	1	-
2	Explain EV and EHV configurations and the electric propulsion systems used in them.	1	-
3	Identify various type of sources that can be used in EV and EHV	1	-
4	Compare the electric power supply and infrastructure used with EV and EHV, distinguish different types of fuel cells used in this industry and verify their suitability.	1	-
5	Compare different types of power electronic converters and inverters used in EV and EHV industry.	1	-

MODULE-1	**14 Hrs**

Introduction to Electric Vehicles: History of Electric Vehicles (EV), Hybrid Electric Vehicles (EHV) and Fuel Cell Vehicles. Social and environmental importance of electric and hybrid electric vehicles – air pollution, global warming, impact of modern drive-trains on energy supplies.

Types of Electric Vehicles: Battery Electric Vehicles, IC Engine/Electric Hybrid Vehicle, Fuelled EVs, EVs using Supply Lines, EVs which use Flywheels or Supercapacitors, Solar-Powered Vehicles, Vehicles using Linear Motors, EVs for the Future

MODULE-2	**12 Hrs**

Configuration of EV's and EHV's: Configurations of EVs, Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains - Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains and series-parallel Hybrid Electric Drive Trains

Electric Propulsion Systems: DC Motor Drives, Induction Motor Drives, Permanent Magnetic BLDC Motor Drives, SRM Drives

MODULE-3	**14 Hrs**

Sources: Batteries, Battery Parameters, Lead Acid Batteries, Nickel-Based Batteries, Sodium-Based Batteries, Lithium Batteries, Battery Charging, Battery Management System.

Electric Supply: Normal Existing Domestic and Industrial Electricity Supply, Infrastructure needed for charging Electric Vehicles, Electricity supply Rails, Battery swapping

MODULE-4	**12 Hrs**

Fuel Cells: Operating principles of fuel cells, Fuel cell technologies, fuel supply, non-Hydrogen fuel cells

Automotive Power Electronic Converters: DC-DC Converters, DC/AC Inverters - Voltage Source Inverters, Current Source Inverters, Multilevel Inverters, AC/AC Converters - Indirect AC/AC Converter, Direct AC/AC Converter

Reference Books:

1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, John Wiley & Sons Ltd, 2nd ed.,2012.
2. John G. Hayes, G. Abas Goodarzi, *Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid,*
3. *Electric and Fuel Cell Vehicles*, John Wiley & Sons Ltd, 2018
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press Taylor & Francis Group, 2004.
5. Ali Emadi, *Handbook of Automotive Power Electronics and Motor Drives,* CRC Press Taylor & Francis Group, 2005

Course Title	Modern Power System Protection		
Course Code	19EE853	L-T-P	(3-0-0)3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course objective: The students will understand, analyse and familiarize themselves with the modern power system protection schemes.

Course outcomes: The student will be able to

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Explain different protection schemes provided in power system	1	-
2	Analyze different relay characteristics required for protection scheme	1	-
3	Explain the principle of operation of components used for implementing protection systems	1	-
4	Examine the role of different protective devices and Relay co-ordination in transmission and distribution system	1	1
5	Interpret practical problems, recent developments and future trends associated with power system protection	1	-

MODULE-1 **10 Hrs**

Introduction to protection: Protection system and its attributes, sensitivity, selectivity, speed, reliability& dependability. Over current relay, directional over current relay, Distance Relay characteristics.

Protective Relaying Principles: Requirements of protective relaying, zones of protection, primary and backup protection, essential qualities of protective relaying, evolution of protective relays, Historical perspectives, classification of protective relaying, A concise introduction to electromechanical relays, static relays, microprocessor-based relays and numerical relays, Digital Relays

MODULE-2 **10 Hrs**

Numerical protection: Introduction, block diagram of a numerical relay, sampling theorem, Fourier analysis of discrete signals, numerical over-current protection.

Distance protection of transmission lines: - Introduction, impedance relay, reactance relay, mho relay, Three stepped distance protection, Protection of three phase lines against all faults.

MODULE-3 **10 Hrs**

Induction motor protection -protection against electrical faults (such as phase fault, ground fault) and abnormal operating conditions (such as single phasing, phase reversal, overload)

Transformer protection - types of faults, over current protection, differential protection, differential relay with harmonic restraint, protection against high resistance ground faults, interturn faults, Buchholtz relay.

MODULE-4 **10 Hrs**

Generator protection: Protection against stator & rotor faults, and abnormal operating conditions (such as unbalanced loading, loss of excitation, over speeding) Bus bar protection by differential protection method.

Computer Relaying in Power System: Introduction to computer relaying, Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Analog to digital converters, Anti-aliasing filters, Substation computer hierarchy, Introduction to embedded power system protection.

Text Books:

1. Y.G.Paithankar and S.R.Bhide, Fundamentals of Power system protection, PHI private limited,NewDelhi,2010.
2. Arun G Phadke and James Thorp Computer Relaying for power systems, Wiley Publications 2nd Edn.
3. Bhavesh Bhalja and R P Mahashwari Protection and Switchgear, Oxford University press

REFERNECE BOOKS:

1. Horowitz and Padke, Power System Relaying
2. T S Madhava Rao, Power system protection, static relays with microprocessor applications, TMH, 2nd edition.
3. Badriram and Vishwakarma, Power system protection & Switch Gear, TMH publications,
4. Ravindranath and Chander, Power System Protection & Switch Gear, New Age Publications.

Course Title	**Energy Auditing and Demand Side Management**		
Course Code	**19EE854**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: The students will perform energy auditing and provide techniques to reduce energy consumption.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Gain the knowledge relating to energy, situation of energy and its consumption.	1	-
2	Identify the elements of energy auditing and electrical system optimisation.	1	-
3	Explain the concept of demand side management and apply its techniques.	1	-
	Explain about the energy efficient motors, electrical tariff, lighting basics and load priority techniques	1	-

MODULE-1	**10 Hrs**

Introduction, Energy Sources, Different types and its Applications. Energy situation – world and India, energy consumption, conservation. Payback analysis, Depreciation (Problems)

Self study: Electrical codes and Standards

MODULE-2	**10 Hrs**

Energy Auditing: Introduction, Elements of energy audits, energy use profiles, measurements in energy audits, presentation of energy audit results.

Electrical System Optimization: The power triangle, Motor horsepower, Power flow concept. Electrical Equipment and power factor –correction.

Self study:: location of capacitors

MODULE-3	**10 Hrs**

Demand Side Management: Introduction to DSM, concept of DSM, benefits of DSM, different techniques of DSM – time of day pricing, multi-utility power exchange model, time of day models for planning.

Self study: DSM based on season

MODULE-4	**10 Hrs**

Energy efficient motors, Lighting basics, Electrical rate tariff. Load management, Load priority technique, Peak clipping, Peak shifting, Valley filling, Strategic conservation, energy efficient equipment.

Self study: Seasonal pricing of Tariff

1. **Text books:** Larry C. White, Philip S. Schmidt, David R. Brown, Industrial Energy Management Systems, Hemisphere Publishing Corporation, New York.

2. Albert Thumann, Fundamentals of Energy Engineering, Prentice Hall Inc, Englewood Cliffs, New Jersey.
1. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education, Private Limited, 2nd edition

Reference Book:

1. D.P.Sen, K.R.Padiyar, Indrane Sen, M.A.Pai, Recent Advances in Control and Management of Energy Systems, Interline Publisher, Bangalore, 1993.
2. Jyothi Prakash, Demand Side Management, TMH Publishers.
3. Hand book on energy auditing - TERI (Tata Energy Research Institute.

Course Title	**Embedded Systems**		
Course Code	**19EE855**	**L-T-P**	**(3-0-0)3**
Exam	**3 Hrs.**	**Hours/Week**	**3 Hrs.**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students shall be trained to use embedded systems for developing a dedicated system application.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO'
1	Gain basic knowledge of embedded systems.	1	-
2	Learn about standard single purpose processors-peripherals for the dedicated tasks.	1	-
3	Learn software architectures of embedded system for the real time tasks.	2	-
4	Learn interfacing peripherals and memory with microprocessor/microcontroller to develop an embedded system.	2	2

MODULE –1	**10 Hrs.**

Concept of embedded system design: Components, classification, skills required. Embedded Micro controller cores: Architecture of 6808 and 6811. Embedded Memories ROM variants, RAM. Applications of embedded system

MODULE – 2	**10 Hrs.**

Technological aspects of Embedded System: Interfacing between analog and digital blocks, Signal conditioning, digital signal processing, DAC & ADC interfacing, Sample & hold, multiplexer interface Internal ADC interfacing (excluding 6805 & 6812

MODULE – 3	**10 Hrs.**

Software aspects of Embedded Systems, real time programming Languages, operating systems. Programming concepts and embedded programming in C. Round Robin, Round Robin with interrupts, function queue-scheduling architecture.

MODULE – 4	**10 Hrs.**

Subsystem interfacing with external systems user interfacing, Serial I/O devices, Parallel port interfaces: Input switches, Key boards and Memory interfacing

Industry Based Elective (Online)

Course Title	Indian Electricity Acts and Implications		
Course Code	19IEE81	L-T-P	(2-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: The students will accept and adopt the Indian Electricity Rules and Acts in their Professional life

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSOs
1.	To interpret the Indian Electricity laws and Acts	1	1
2.	To compare & explain functional set up of power sector at national and state level	1	-
3.	To outline the provisions relating to Electricity generation transmission & distribution	1	1
4.	To explain about the provisions relating to safety and supply of Electricity to consumers.	1	1
5.	To analyze the provisions relating Electricity Trading and power business and Tariffs	1	1

MODULE-1 **10 Hrs.**

Overview of Power Sector : Electricity Scenario at National Level and State Level with Key Statistics relating to Generation, Transmission and Distribution of power

Organizational Set up and Introduction to Electricity Laws – A brief discussion on functional set up of power sector at national and state level and connectivity among different statutory entities and introduction to EA 2003, EC 2001 and KER Act 1999

Over View of Regulations Governing Electricity Generation and Transmission – A brief description of Key regulations issued by CERC and KERC on Generation and Transmission activity.

Over View of Regulations Governing Distribution & Trading - A brief description of key regulations issued by CERC and KERC on Distribution and Trading activity.

MODULE-2 **10 Hrs.**

Provisions relating to Electricity Generation in Act 2003 and related case studies Sn 7, 8, 9, 10 & 11.

Provisions relating to Grid Operation in Act 2003 and related case Studies Sn 25, 26,27,28, 29, 30, 31, 32, 33 , 34

Provisions Relating to Electricity Transmission and related cases Sn38, 39, 40, 41

MODULE-3 **10 Hrs.**

Provisions Relating to Electricity Distribution in Act 2003 and related case studies : Sn 42, 43, 55, 56 , 135.

Key Technical Aspects relating to supply of electricity and supply code.

MODULE-4 **12 Hrs.**

Safety in Supply of Electricity - Regulations and Case studies - Safety Regulations issued by CEA. Electricity Trading and Power Business Trading Regulations issued by CERC and KERC, & Case Studies.

Electricity Tariffs – Provisions in the Act, related regulations and case studies; Sn 61, 62, 63, 64 & 65.

Reference Books:

1. Sathpal Puliani: The Electricity Act 2003, Karnataka Law Journal Publications, 2014
2. KER Act 1999, IEGC, KEGC, KEDC
3. Regulations issued by KERC , Tariff Orders issued by KERC.

Course Title	Communication Protocols in Power Systems		
Course Code	19IEE82	L-T-P	(2-0-0) 2
Exam	2 CIE	Hours/Week	2
CIE	50 Marks	Total Hours	26

Course Objective: Students will be able to understand about various communication protocols used power system automation

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Understand the fundamental of type of communications	1	
2	Apply various types of serial communication protocols in power systems	1, 2, 5,12	1
3	Apply various types of TCP/UDP based communication protocols in power systems	1, 2, 5,12	1

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MODULE-1	4 Hrs.

Fundamental of Communication: Fundamental of Communications, Mediums, Protocols, Type of networks and OSI Layer communication stack

MODULE-2	8 Hrs.

Modes of Communications: Introduction to serial communication, serial communication protocols like RS232, RS435, Introduction to IP based communication methodologies like UDP/IP, TCP/IP. Hands on practical examples

MODULE-3	8 Hrs.

Deep dive into Power System Protocols: Fundamentals of DNP 3.0, Understanding ModBus Serial, ModBus TCP protocols, Protocols for IED (MMS, GOOSE)

MODULE-4	6 Hrs.

Latest Communication Protocols: Interoperability using, IEC 61850, Open API integration using Web API (RESTful API), Simple File Transfer Protocols (FTP) and Secure File Transfer Protocols

Text books:

1. Bill Donatelli, Mastering Modbus TCP/IP Network Communications, Jakongrila Publications
2. Andrew S. Tenenbaum, ComputerNetworks, 4th Ed., Pearson Education, 2003. (Link:https://theswissbay.ch/pdf/Gentoomen%20Library/Networking/Prentice%20Hall%20-%20Computer%20Networks%20Tanenbaum%204ed.pdf)

References:

1. http://trianglemicroworks.com/training/protocol-training