Maharaja Ranjit Singh Punjab Technical University
Bathinda-151001

FACULTY OF ENGINEERING AND TECHNOLOGY

SYLLABUS

FOR

M.TECH. ELECTRICAL ENGINEERING (POWER SYSTEM)
2022 BATCH ONWARDS

(For Full-Time and Part-Time Modes)

(ii) Subject to change in the syllabi at any time.

Please visit the University website time to time.

Study Scheme for M.Tech Regular Programme

1st Semester		Contact Hrs.			Marks			Credits
Subject Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-101	Advanced Power System Analysis	4	0	0	40	60	100	4
MELES2-102	Electrical Power Distribution System	4	0	0	40	60	100	4
MELES2-103	Electric and Hybrid Vehicles	4	0	0	40	60	100	4
MELES2-104	Power System Lab - I	0	0	4	60	40	100	2
Departmental Elective-I		4	0	0	40	60	100	4
MELED2-111	Restructured Power Systems							
MELED2-112	Energy Management and Energy Auditing							
MELED2-113	Artificial Intelligence Techniques							
Departmental Elective-II		4	0	0	40	60	100	4
MELED2-121	Industrial Load Modeling and Control							
MELED2-122	Advanced AC/DC LV/MV Drive Systems							
MELED2-123	Power System Transients							
Total		**20**	**0**	**4**	**260**	**340**	**600**	**22**

2nd Semester		Contact Hrs.			Marks			Credits
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-201	Advanced Protection of Power System	4	0	0	40	60	100	4
MELES2-202	Power System Dynamics & Stability	4	0	0	40	60	100	4
MELES2-203	Smart Grids	4	0	0	40	60	100	4
MELES2-204	Power System Lab-II	0	0	4	60	40	100	2
Departmental Elective-III		4	0	0	40	60	100	4
MELED2-211	Power Quality							
MELED2-212	FACTS and Custom Power Devices							
MELED2-213	Digital Transformation in Industry							
Departmental Elective-IV		4	0	0	40	60	100	4
MELED2-221	Renewable Energy System and Distributed Generation							
MELED2-222	SCADA System and Applications							
MELED2-223	Optimization Techniques for Power Engineering							
Total		**20**	**0**	**4**	**260**	**340**	**600**	22

3rd Semester	Contact Hrs.	Marks	Credits

Code	Course	L	T	P	Int.	Ext.	Total	
MELES2-301	Project	0	0	--	60	40	100	6
MELES2-302	Seminar	0	0	2	100	--	100	1
MREMI0-101	Research Methodology & IPR	4	0	0	40	60	100	4
XXXXXX	Open Elective – (To be selected from the list of PG open electives from emerging technical areas and not from Humanities and Social Sciences)	3	0	0	40	60	100	3
Total		**7**	**0**	**2**	**240**	**160**	**400**	14

4th Semester		**Contact Hrs.**			**Marks**		
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext**	**Total**
MELES2-401	Dissertation	--	--	--	**Satisfactory / Not Satisfactory as per CBCS-2016**		
Total		--	--	--	--		

Study Scheme for M.Tech. Part-Time Programme

1st Semester		Contact Hrs.			Marks			Credits
Subject Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-102	Electrical Power Distribution System	4	0	0	40	60	100	4
MELES2-103	Electric and Hybrid Vehicles	4	0	0	40	60	100	4
Departmental Elective-I		4	0	0	40	60	100	4
MELED2-111	Restructured Power Systems							
MELED2-112	Energy Management & Energy Auditing							
MELED2-113	Artificial Intelligence Techniques							
Total		**12**	**0**	**0**	**120**	**180**	**300**	**12**

2nd Semester		Contact Hrs.			Marks			Credits
Subject Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-101	Advanced Power System Analysis	4	0	0	40	60	100	4
MELES2-104	Power System Lab - I	0	0	4	60	40	100	2
Departmental Elective-II		4	0	0	40	60	100	4
MELED2-121	Industrial Load Modeling and Control							
MELED2-122	Advanced AC/DC LV/MV Drive Systems							
MELED2-123	Power System Transients							
Total		**8**	**0**	**4**	**140**	**160**	**300**	10

3rd Semester		Contact Hrs.			Marks			Credits
Subject Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-201	Advanced Protection of Power System	4	0	0	40	60	100	4
MELES2-203	Smart Grids	4	0	0	40	60	100	4
Departmental Elective-III		4	0	0	40	60	100	4
MELED2-211	Power Quality							
MELED2-212	FACTS and Custom Power Devices							
MELED2-213	Digital Transformation in Industry							
Total		**12**	**0**	**0**	**120**	**180**	**300**	**12**

4th Semester		**Contact Hrs.**			**Marks**			**Credits**
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-202	Power System Dynamics & Stability	4	0	0	40	60	100	4
MELES2-204	Power System Lab-II	0	0	4	60	40	100	2
Departmental Elective-IV		4	0	0	40	60	100	4
MELED2-221	Renewable Energy System & Distributed Generation							
MELED2-222	SCADA System & Applications							
MELED2-223	Optimization Techniques for Power Engineering							
Total		**8**	**0**	**4**	**140**	**160**	**300**	**10**

5th Semester		**Contact Hrs.**			**Marks**			**Credits**
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELES2-301	Project	0	0	--	60	40	100	6
MELES2-302	Seminar	0	0	2	100	--	100	1
MREMI0-101	Research Methodology & IPR	4	0	0	40	60	100	4
XXXXXX	Open Elective – (To be selected from the list of PG open electives from emerging technical areas and not from Humanities and Social Sciences)	3	0	0	40	60	100	3
Total		**7**	**0**	**2**	**240**	**160**	**400**	**14**

6th Semester		**Contact Hrs.**			**Marks**		
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**
MELES2-401	Dissertation	--	--	--	**Satisfactory / Not Satisfactory as per CBCS-2016**		
Total		**--**	**--**	**--**	**--**		

ADVANCED POWER SYSTEM ANALYSIS

Subject Code: MELES2-101 **L T P C** **Duration: 60 Hrs.**
4 0 0 4

Course Objectives: Students will be able to:
Study various methods of load flow and their advantages and disadvantages.
Understand how to analyze various types of faults in power system.
Understand power system security concepts and study the methods to rank the contingencies.
Understand need of state estimation and study simple algorithms for state estimation.
Study voltage instability phenomenon.
Course Outcomes: Students will be able:
To do load flow analysis using various methods and economic operation of power system.
To calculate fault currents.
To know about automatic generation and voltage control.
To rank various contingencies according to their severity for security analysis.
To estimate state of power system by various methods.

UNIT-I (15 Hrs.)

Load Flow: Network modeling, Overview of Newton-Raphson, Gauss-Siedel, Decoupled and Fast decoupled methods, convergence properties, three-phase load flow, AVR in load flow.
Economic operation of Power System:
Economic dispatch including transmission losses using lambda iteration method, Solution of Coordination Equations, Formulation of optimal power flow-solution by Gradient Method, Newton's method.
Unit Commitment: Constraints in unit commitment (UC), Methods for UC; Priority list method and Dynamic programming.

UNIT-II (15 Hrs.)

Fault Analysis: Analysis of balanced and unbalanced three phase faults, Fault calculations, Short circuit faults, Open circuit faults, Generalized method of fault analysis.
Digital Techniques in Fault Calculations: Algorithm for formulation of bus impedance matrix, Equations and Flow chart for short circuit studies, Calculation of line currents, mutually coupled branches in Z_{BUS}.

UNIT-III (15 Hrs.)

Automatic generation control: Introduction, Load frequency control (single area and Two area) and economic dispatch control, Optimal load frequency control, Load frequency control with generation rate constraints,
Voltage Control: Effect of reactive power transmission on voltage, Surge impedance loading and voltage stability limit, P-V curve and V-Q curve, Voltage collapse, Prevention of voltage collapse, Voltage collapse proximity indices, Automatic voltage control of alternator.

UNIT- IV (15 Hrs.)

Security Analysis: Factors affecting power system security, Security state diagram, Contingency analysis, Sensitivity factors; generator shift distribution factors, line outage distribution factors, multiple line outages, Overload performance index ranking.
State Estimation: Introduction to power system state estimation, Weighted least squares estimation, State estimation of an AC network, State estimation by orthogonal decomposition and its algorithm, Detection and identification of bad measurements, Virtual and pseudo measurements, network observability and Pseudo-measurements, Application of power systems state estimation.

Recommended Books:

1. A.J. Wood, Bruce F. Wollenberg, ‘Power Generation, Operation and Control’, John Wiley, **2009.**
2. D.P. Kothari & I.J. Nagrath, Modern Power System Analysis, Tata McGraw Hill, 2012.
3. J.J. Grainger and W.D. Stevenson, ‘Power System Analysis’, McGraw Hill, **2003**.
4. R. Bergen and Vijay Vittal, ‘Power System Analysis’, Pearson, **2000**.
5. L.P. Singh, ‘Advanced Power System Analysis and Dynamics’, New Age International, 2006.
6. G.L. Kusic, ‘Computer aided Power System Analysis’, Prentice Hall India, **1986**.
7. P.M. Anderson, ‘Faulted Power System Analysis’, IEEE Press, **1995**.
8. J. Arrillaga and C.P. Arnold, ‘Computer Analysis of Power Systems’, John Wiley and Sons, NewYork, 1997.
9. M.A. Pai, ‘Computer Techniques in Power System Analysis’, Tata McGraw hill, New Delhi, 2006.
10. Dr. B.R. Gupta, Power System Analysis and Design, S. Chand & Company, 2014.

ELECTRICAL POWER DISTRIBUTION SYSTEM

Subject Code: MELES2-102 **L T P C** **Duration: 60 Hrs.**
4 0 0 4

Course Objectives: Students will be able to:
Learning about power distribution system.
Learning of SCADA System.
Understanding Distribution Automation.
Course Outcomes: Students will be able to:
Understand of power distribution system.
Study of Distribution automation and its application in practice.
To learn SCADA system.

UNIT-I (15 Hrs.)

System Planning: Introduction, Distribution system planning, Factors affecting system planning, present planning techniques, planning models, Introduction to optimum line network, future trends in planning, systems approach, distribution automation.
Load Characteristics: Basic definitions, Relation between load and loss factors, Maximum diversified demand, Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long- term, Power system loading, Technological forecasting.

UNIT-II (15 Hrs.)

System Design and Operation: Criteria, system developers, dispersed generation, distribution systems, economics and finance, mapping, Design of substation and feeder, Operation criteria voltage measurements, harmonics, load variations, system losses, Introduction to energy management.
Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring.

UNIT-III (20 Hrs.)

Distribution Automation: Advantages of Distribution Management System (D.M.S.) Definition, Restoration/Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction.
Maintenance of Automated Distribution Systems: Difficulties in Implementing Distribution, Automation in Actual Practice, Urban/Rural Distribution, Energy Management, introduction to AI techniques applied to Distribution Automation.
Voltage Regulation and Automation: Quality of Service and Voltage Standards, Voltage Control, Line Drop Compensation, Distribution capacitor automation, Voltage fluctuations,
SCADA and Communication with Load Dispatch Centers: Interconnection of Distribution, Control & Communication Systems, Remote Metering, Smart meter and Automatic Meter Reading and its implementation.

UNIT-IV (10 Hrs.)

Distribution System Protection: Objective of distribution system protection, high impedance faults coordination of protective devices: fuse to fuse co-ordination, re-closer to re-closer coordination, re-closer to fuse coordination, re-closer to substation transformer high side fuse coordination, fuse to circuit breaker coordination, re-closer to circuit breaker coordination, Lightning protection.

Recommended Books:

1. A.S. Pabla, 'Electric Power Distribution', 6th Edn., Tata McGraw Hill Publishing Co. Ltd.,

2011
2. M.K. Khedkar, G.M. Dhole, 'A Text Book of Electrical Power Distribution Automation', University Science Press, New Delhi.
3. Anthony J. Panseni, 'Electrical Distribution Engineering', CRC Press.
4. James Momoh, 'Electric Power Distribution, Automation, Protection & Control', CRC Press.
5. Gonen, Turan, 'Electric Power Distribution System Engineering', CRC PRESS, Third Indian Reprint, **2012**.
6. Thomas Allen Short , 'Electric Power Distribution Handbook'**.**

ELECTRIC AND HYBRID VECHILES

Subject Code: MELES2-103 **L T P C 4 0 0 4** **Duration: 60 Hrs.**

Course Objectives: Students will be:
Introduced to conventional and hybrid electric vehicles.
Introduced to the Electric Propulsion unit and DC/AC drives.
Made familiar with electric and hybrid drive trains and sizing of the drive system.
Able to learn about energy storage in Hybrid and Electric Vehicles.
Course Outcomes: Students will be able to:
Acquire knowledge about conventional and hybrid electric vehicles.
Acquire knowledge about Electric Propulsion unit and DC/AC drives.
Match the electric machine and the internal combustion engine.
Estimate about energy storage requirements in Hybrid and Electric Vehicles.

UNIT-I (10 Hrs.)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, Mathematical models to describe vehicle performance.
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT-II (20 Hrs.)

Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives.
Introduction to DC Motor Drives: Review of Four quadrant operation of a DC machine; Steady-state operation of multi-quadrant chopper fed DC drive, regenerative braking, Introduction to various PM motors, BLDC and PMSM drive configurations and their speed and torque control.
Introduction to AC Motor Drives: Voltage fed inverter control-V/f control, Vector control, direct torque and flux control (DTC) of induction machines, Open loop v/f control, vector control, direct torque control of synchronous motor drives.

UNIT-III (15 Hrs.)

Electric Drive-Trains: Basic concept of electric traction, Various electric drive-train topologies, Power flow control in electric drive-train topologies, Fuel efficiency analysis.
Hybrid Electric Drive-Trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
Sizing the Drive System: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

UNIT-IV (15 Hrs.)

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies.

Recommended Books:

1. Iqbal Hussain, 'Electric and Hybrid Vehicles', CRC Press, 2nd Eddition, 2010.

2. A.K. Babu, 'Electric and Hybrid Vehicles', Khanna Publishers, 2019.
3. Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer.
4. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding Mode Control of Switching Power Converters'.

POWER SYSTEM LAB-I

Subject Code: MELES2-104 **L T P C** **Duration: 60 Hrs.**
0 0 4 2

Course Objectives: To make the students able:
To do the load flow analysis using various methods.
To plan the economic operation of power systems by finding optimum loading schedule of the generators and to optimally commit the generating units.
To calculate fault currents.
To evaluate transient stability of single/ multi-machines connected to infinite bus.
To simulate automatic generation and voltage control and load frequency control.
Course Outcomes: Students will be able to use the relevant software for programming:
To do the load flow analysis using various methods.
To plan the economic operation of power systems by finding optimum loading schedule of the generators and optimal unit commitment.
To calculate fault currents. Also, to evaluate transient stability of machines connected to infinite bus.
To simulate automatic generation control and load frequency control.

LIST OF EXPERIMENTS
NOTE: Students should be made familiar with one or more available programming language/software like MATLAB, ETAP, GAMS, Power System Toolbox, Power world Simulator, Network Simulator, LABVIEW, etc. so as to develop programs using one or more of these for:

1. Review of basics of the available programming language.
2. Load flow analysis by using Gauss Seidel (G-S) method.
3. Load flow analysis by using Newton-Raphson (N-R) method.
4. Load flow analysis by using decoupled and fast decoupled N-R method.
5. Short circuit Fault analysis.
6. Economic dispatch of power generation.
7. To find optimum loading of generators neglecting transmission losses.
8. To find optimum loading of generators with penalty factors.
9. Optimal unit commitment.
10. Simulink model of single area load frequency control with and without PI controller.
11. Simulink model for two area load frequency control.
12. Simulink model for evaluating transient stability of single/multi machine connected to infinite bus.
13. Simulation of automatic generation control.

RESTRUCTURED POWER SYSTEM

Subject Code: MELED2 – 111 **L T P C** **4 0 0 4** **Duration: 60 Hours**

Course Objectives: To make the students to:
To introduce the concept of restructuring of the electricity market and its components
To make the students familiar about the deregulation of the electricity market
To introduce the concept of the Competitive Wholesale Electricity Markets
To make the students familiar about Transmission Open Access in electricity markets
Course Outcomes: Students will be able to:
To describe the process of restructuring of the electricity market
To understand the process of deregulation of the electricity market
To understand concept, types and challenges in Competitive Wholesale Electricity Markets
To understand the concept of Transmission Open Access in electricity markets

UNIT-I (15 Hrs.)

Components of Restructured Power System
Introduction, The Traditional Power Industry, Motivations for Restructuring the Power Industry, Unbundling Generation, Transmission and Distribution, Components of Restructured Power System (BOT Plant Operators & Contracted IPPs, Discos & Retailers, Transmission Owners (TOs), Independent System Operator (ISO), Power Exchange (PX), Scheduling Coordinators (SCs), PX Functions and Responsibilities, California Power Exchange, ISO Functions and Responsibilities, Classification of ISO types.

UNIT-II (15 Hrs.)

Deregulation of Electric Utilities
Introduction of Deregulation, Traditional Central Utility Model, Reform Motivations, Separation of Ownership and Operation, Central Dispatch Versus Market Solution, Competition and Direct Access in the Electricity Market (Energy Market and Auction Mechanisms), Direct Access/Wheeling, Independent System Operator (Pricing and Market Clearing, Risk Taking), Retail Electric Providers, Different Experiences of deregulation of England & Wales, Norway, California, Scotland, The European Union and Germany and New Zealand.

UNIT-III (15 Hrs.)

Competitive Wholesale Electricity Markets:
Introduction, Wholesale Electricity Market Characteristics (Small Test System, Central Auction, Bidding, Market Clearing and Pricing, Market Timing, Sequential and Simultaneous Markets, Bilateral Trading, Scheduling, Gaming, Ancillary Services, Physical and Financial Markets), Market models (Maximalist ISO, Minimalist ISO Model), Challenges (Market Power Evaluation and Mitigation, System Capacity, Reliability, Technical Issues).

UNIT-IV (15 Hrs.)

Transmission Open Access
Introduction, Trading Arrangements (The Pool, Pool and Bilateral Trades, Multilateral Trades) Transmission Pricing in Open-access Systems (Introduction, Rolled-in Pricing Methods. Incremental/ Marginal Pricing Methods, Embedded Cost Recovery, Transmission Pricing Method in the NGC & UK), Open Transmission System Operation, Dispatch, Transmission Loss Compensation (System Control, Ancillary Service Provision), Congestion Management in Open-access Transmission Systems (Normal Operation, Integrated Transmission Dispatch Strategy, Illustration Using a Small Power System), Open Access Coordination Strategies (Price Elasticity, ISO Executed Price Signalling, Coordination between Transactions, Illustration of Transaction Procedure and Integrated Coordination Procedure)

Recommended Books:

1. Loi Lei Lai, ‘Power System Restructuring and Deregulation’, John Wiley & Sons Ltd., 2002.
2. Lorrin Philipson, H. Lee Willis, ‘Understanding Electric Utilities and De-regulation’,_Marcel Dekker, 1998.
3. **Gan Donghan Feng; Jun Xie, ‘Electricity Markets And Power System Economics by; T&F India.**
4. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, ‘Operation of Restructured Power Systems’, Kluwer Academic Pub.,2001.
5. Mohammad Shahidehpour, Muwaffaq Alomoush, ‘Restructured Electrical Power Systems: Operation, Trading and Volatility’, Marcel Dekker.

ENERGY MANAGEMENT AND ENERGY AUDITING

Subject Code: MELED2 – 112 **L T P C 4 0 0 4** **Duration: 60 Hours**

Course Objectives: Students will be able to:
To understand the need for energy auditing
Understanding of various loads involved based on power consumption for auditing
To know about different audit instruments used in practice.
Course Outcomes: Students will be able:
To acquire the skills and techniques required to implement energy management. Able to perform Basic Energy Audit in an Organization.
To calculate different types of losses and hence evaluate and improve the energy efficiency of electric motors and transformers.
To apply Energy Efficient Technologies in Electrical Systems. Energy saving opportunities with energy efficient motors
Identify and quantify the energy intensive business activities in an organization.

UNIT – I (15 Hrs.)

Energy Scenario: Commercial and non-commercial energy, Primary energy resources, Commercial energy production, Final energy consumption, Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment, Energy security, Energy conservation and its importance, Restructuring of the energy supply sector, Energy strategy for the future, Air pollution, Climate change, Energy Conservation Act-2001 and its features.
Energy Management and Audit: Definition, Energy audit, Need, Types of energy audit, Energy management (audit) approach, Energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel & energy substitution, Energy audit instruments, Material and energy balance, Methods for preparing process flow and Material and energy balance diagrams.

UNIT – II (15 Hrs.)

Electric motors: Energy efficient controls and starting efficiency, Motor Efficiency and Load, Analysis Energy efficient /high efficient Motors, Load Matching and selection of motors, Losses in induction motors, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors
Transformer: Loading/Efficiency analysis, Feeder/cable loss evaluation, case study, Reactive Power management-Capacitor, Sizing-Degree of Compensation-Capacitor losses, Location-Placement, Maintenance, Case study.

UNIT- III (15 Hrs.)

Energy Efficiency in Electrical Systems: Electrical system, Electricity tariffs, Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors.
Energy Efficient Technologies in Electrical Systems: Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology.

UNIT – IV (15 Hrs.)

Electric loads of Air conditioning &Refrigeration: Energy conservation measures- Cool storage, Types-Optimal operation, case study.
Electric water heating: Geysers-Solar Water Heaters, Power Consumption in Compressors, Energy conservation measures, Electrolytic Process, Computer Controls- software-EMS

Energy Efficiency in Industrial Systems: Types, Performance evaluation, Efficient system operation, Flow control strategies and energy conservation opportunities in Fans and Blowers, Pumps and pumping system, Cooling tower.

Recommended Books:

1. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)
2. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2ndedition (1994)
3. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwerinternational series -207,1999
4. Y P Abbi and Shashank Jain, Handbook on Energy Audit and Environment Management , TERI,2006
5. Albert Thumann, William J. Younger, Terry Niehus, Handbook of Energy Audits 2009

ARTIFICIAL INTELLIGENCE TECHNIQUES

Subject Code: MELED2 – 113 **L T P C 4 0 0 4** **Duration: 60 Hours**

Course Objectives: To make the students to:
To understand basics of AI & Soft computing techniques.
Learn the concepts of biological foundations of artificial neural networks.
Understand Genetic Algorithm and Evolutionary programming.
Understand, fuzzy logic and fuzzy neural networks.
Learn to apply these techniques to practical problems.
Course Outcomes: The students will acquire the skills:
To apply artificial neural networks in various electrical and electronics engineering applications.
To apply Genetic Algorithm and Evolutionary programming to solve engineering problems.
To take up fuzzy systems approach to solve applications in engineering.
Required to innovate and build, smart and intelligent applicationsin industrial control systems by using all these methods.

UNIT-1 (15 Hrs.)

Artificial Neural Networks: Artificial Neuron models, Types of activation functions, Neural network architectures, Neural Learning: Correlation, Competitive, Feedback based weight adaptation, Evaluation of networks, Generalizability, Computational resources, Supervised learning: Perceptron's, linear separability, Multilayer networks, Back propagation algorithm and its variants, Unsupervised learning, Winner–take all networks, Adaptive resonance theory, Self-organizing maps, Hopfield networks, Typical application in identification, Optimization, and other industrial control methods.

UNIT-II (15 Hrs.)

Fuzzy Logic: Fuzziness vs probability, Crisp logic vs fuzzy logic, Fuzzy sets and systems, Operations on sets, Fuzzy relations, Membership functions, Fuzzy rule generation, Defuzzification, Mamdani and Takagi-Sugeno Model, Fuzzy controllers.
Database – rule base – Inference engine.
Genetic Algorithm (GA): Introduction, Working principle, Coding of variables, Fitness function, Comparison with traditional methods, Constraints and penalty function, GA operators; reproduction, cross over, mutation, Real coded GA, Applications of GA in optimization and to practical problems.

UNIT-III (15 Hrs.)

Evolutionary Computation: Introduction to optimization problem, Constraints, Objective functions, Unimodal / multimodal problems, Classical v/s Evolutionary computational techniques, Genetic Algorithms and its Operators,
Introduction to Advanced AI techniques: Particle Swarm Optimization, Ant Colony Optimization, Differential Evolution Hybrid techniques; Fuzzy Genetic, Genetic-Neural networks etc.

UNIT-IV (15 Hrs.)

Associative Models And Control Schemes In Nn
Auto & hetero associative memory – bi-directional associative memory – Self organizing feature Maps-Hopfield Networks-Neural Networks for non – linear system – Schemes of Neuro control – System identification – forward model and – Inverse model – Case studies.
Applications: Applications of Neural network, Fuzzy system & Genetic algorithms for power systems and powerelectronics Systems-Designing of controllers using Simulation Software, NN tool box & Fuzzy Logic Toolbox.
Recommended Books:

1. N.P. Padhy, 'Artificial Intelligence and Intelligent Systems', Oxford University Press, 2005.
2. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, Pearson Education.
3. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problem solving", Fourth Edition, Pearson Education.
4. J.M. Zurada, 'An Introduction to ANN', Jaico Publishing House, West, **1992**.
5. Simon Haykins, 'Neural Networks', Pearson Prentice Hall, **2005.**
6. Awrence Fausatt, 'Fundamentals of Neural Networks', Prentice Hall of India, New Delhi, **1994**.
7. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', McGraw Hill International Edition, USA, **1997**.
8. Driankov, Dimitra, 'An Introduction to Fuzzy Control', Narosa Publication.
9. Davis E. Goldberg, 'Genetic Algorithms in Search, Optimization, and Machine Learning', Adison Willey Publishing Company, **1989**.
10. Siva Nandam, 'Introduction to Fuzzy Logic using MATLAB', Springer Science & Business Media, **2006**.

INDUSTRIAL LOAD MODELING AND CONTROL

Subject Code: MELED2-121 **L T P C** **Duration: 60 Hours**
4 0 0 4

Course Objectives: To acquaint the students with:
The energy demand scenario.
The modeling of load and to study load demand industrially.
To know electricity pricing models.
Study reactive power management in industries.
Course Outcomes: Students will be able to:
Manage load and pricing in industries.
Manage reactive power in industries and apply different energy saving opportunities in cooling and heating loads.
Apply load management to reduce demand of electricity during peak time.
Knowledge about load control techniques in industries and its application.

UNIT-I (15 Hrs.)

Industrial Load Management: Electric Energy Scenario, Demand side management, Load curves, Load Shaping Objectives, Methodologies, Barriers, Classification of industrial loads, Continuous and Batch processes, Load modeling.
Pricing and Control: Electricity pricing, Dynamic and spot pricing Models, Direct load control, Interruptible load control, Bottom up approach, Scheduling, Formulation of load Models, Optimization and control algorithms, Case studies.

UNIT– II (15 Hrs.)

Reactive Power Management in Industries: Power quality problems and Reactive power compensation at distribution level, Controls, Power quality impacts, Choice of filters, Application of filters, Energy saving in industries.
Cooling and Heating Loads: Load profiling, Modeling cool storage, Types, Control strategies, optimal operation, Problem formulation, Case studies.

UNIT-III (10 Hrs.)

Energy banking, industrial cogeneration and Captive power units: Operating and control strategies, Power Pooling, Operation models, Selection of Schemes, Optimal operating strategies, Peak load saving, Constraints problem formulation, Case study

UNIT– IV (20 hrs)

Integrated Load Control for Industries: Design of Multi-loop Controllers: Interactions and decoupling of control loops, Design of cross controllers and selection of loops using Relative Gain Array (RGA).
Advanced Control Schemes: Structure, analysis and application of Cascade control, Selective control, Ratio Control, Design of steady state and dynamic feed forward controller, Feed forward combined with feedback control, Structure, analysis and applications of inferential control, Dead time and inverse response compensators, Concepts and applications of Adaptive control.

Recommended Books:
1. C.O. Bjork, 'Industrial Load Management - Theory, Practice and Simulations', Elsevier, the Netherlands, **1989.**
2. C.W. Gellings and S.N. Talukdar, 'Load Management Concepts', IEEE Press, New York, 1986.
3. Y. Manichaikul and F.C. Schweppe, 'Physically based Industrial load', IEEE Trans. on PAS, April, **1981.**
4. H.G. Stoll, 'Least Cost Electricity Utility Planning', Wiley Interscience Publication, USA,

1989.
5. I.J. Nagarath and D.P. Kothari, Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995
6. IEEE Bronze Book- 'Recommended Practice for Energy Conservation and Cost Effective planning in Industrial Facilities', IEEE Inc., USA.

ADVANCED AC/DC LV/MV DRIVE SYSTEMS

Subject Code: MELED2-122 **L T P C** **Duration: 60 Hours**
4 0 0 4

Course Objects: To make the students aware about:
The power electronic converters and their control strategies used for DC and AC motor speed control.
The principles of speed-control of DC motors and to apply these methods for speed control of DC drives.
The principles of speed-control of induction motors and to apply these methods for speed control of AC drives.
The principles of speed-control of Synchronous Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motor Drives.
Course Outcomes: students will demonstrate the ability to:
Use the power electronic converters and their control strategies for DC and AC motor speed control.
Understand the principles of speed-control of DC motors and to apply these methods for speed control of DC drives.
Understand the principles of speed-control of induction motors and to apply these methods for speed control of AC drives.
Understand the principles of speed-control of Synchronous Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motor Drives.

UNIT – I (15 hours)

Review of DC Motor Characteristics: Review of e.m.f and torque equations, and torque-speed characteristics of separately excited DC motor, Effect of change in armature voltage and load on torque-speed characteristics, Armature voltage control for varying motor speed, flux weakening for high speed operation.
Chopper Fed DC Drives: Review of DC chopper and duty ratio control, Chopper fed DC motor for speed control and its Steady state operation, Armature current waveform and ripple, Calculation of losses in DC motor and chopper, efficiency of DC drive, smooth starting.

UNIT – II (15 hours)

Multi-quadrant DC Drive: Review of motoring and generating modes operation of a separately excited DC machine, Four quadrant operation of DC machine; single-quadrant, two-quadrant and four-quadrant choppers; Steady-state operation of multi-quadrant chopper fed DC drive, regenerative braking.
Closed-loop control of DC Drive: Control structure of DC drive, Inner current loop and outer speed loop, Dynamic model of DC motor – dynamic equations and transfer functions.

UNIT – III (15 hours)

Review of Induction Motor characteristics: Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, Impact of rotor resistance on the torque-speed curve of slip ring induction motor, Power electronic based rotor side control of slip ring motor, Slip power recovery, Operating point, constant flux operation, flux weakening operation.
Induction Motor Drives: Different transformations and reference frame theory, modeling of induction machines, Voltage fed inverter control-V/f control, Vector control, direct torque and flux control (DTC).
Scalar Control or Constant V/f Control of Induction Motor: Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

UNIT – IV (15 hours)

Synchronous Motor Drives: Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.
Permanent Magnet Motor Drives: Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.
Switched Reluctance Motor Drives: Evolution of switched reluctance motors (SRM), various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

Recommended Books:

1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, 1989.
2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall, 2001.
3. R. Krishnan, " Permanent Magnet Synchronous and Brushless DC motor Drives", CRC Press, 2009.
4. G. K. Dubey, " Fundamentals of Electrical Drives", CRC Press, 2002.
5. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.
6. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.

POWER SYSTEM TRANSIENTS

Subject Code: MELED2-123 **L T P C** **Duration: 60 Hours**
4 0 0 4

Course Objectives: To make the students aware about:
The occurrence of transients in a power system.
The fundamental circuit analysis of electrical transients to know about change in parameters like voltage and frequency during transients.
The Generation of over-voltages on transmission lines due to lightning and switching phenomenon etc. and protection against these over voltages.
About insulation coordination.
Course Outcomes: Students will be able to:
Knowledge of various transients that could occur in power system.
Model the power system for transient analysis.
To design various protective devices in power system for protecting equipment and personnel against over-voltages.
Coordinating the insulation of various equipment in power system.

UNIT- I (15 Hrs.)

Surge parameters of plant: Equivalent circuit representations, Lumped and distributed circuit transients, Types of system transients, Travelling waves and propagation of surges, Reflection and Refraction of travelling waves, Attenuation and distortion of travelling waves, Traveling waves in distributed parameter multi-conductor lines, parameters as a function of frequency, Determination of system voltages produced by travelling waves.
Line energization and de-energization transients: Earth and earth wire effects, Current chopping in circuit breakers, Short line fault condition and its relation to circuit breaker duty, Trapped charge effects, Effect of source and source representationin short line fault studies, Control of transients.

UNIT- II (15 Hrs.)

Fundamental circuit analysis of electrical transients: Laplace Transform method of solving simple Switching transients, Damping circuits, Abnormal switching transients, Three-phase circuits and transients.
Computation of power system transients: Principle of digital computation, Matrix method of solution, Modal analysis, Z transform- Computation using EMTP (electromagnetic transients program).

UNIT- III (15 Hrs.)

Generation of over-voltages on transmission lines: Lightning, switching and temporary over voltages, Physical phenomena of lightning, Effect of lightning on power transmission system, Influence of tower footing resistance and earth resistance, switching: Short line or kilometric fault, energizing transients - closing and re-closing of lines, line dropping, load rejection, over voltages induced by faults.
Protective devices: Protection of system against over voltages, Surge diverters, Lightning arresters, Neutral grounding, Substation earthing, Simulation of surge diverters in transient analysis.

UNIT- IV (15 Hrs.)

Switching of HVDC line: travelling waves on transmission line, Circuits with distributed parameters wave equation, Reflection, Refraction, Behavior of Travelling waves at the line terminations, Lattice Diagrams – attenuation and distortion, Multi-conductor system and Velocity wave.
Insulation Co-ordination: Over voltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs, and metallic contacts.

Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), Coordination between insulation and protection level, Statistical approach.

Recommended Books:

1. Allan Greenwood, 'Electrical Transients in Power System', Wiley & Sons Inc. New York, 1991.
2. J. Arrillaga and C.P. Arnold, 'Computer Aided Power System', John Wiley and Sons, **1994**.
3. Sunil S. Rao, 'Switch Gear Protection and Power System', Khanna Publishers, **2008.**
4. V.A. Vanikov, 'Transients in Power System', Mir Publications, Moscow.
5. L.V. Bewley, 'Traveling Waves on Transmission Lines', Dover Publications Inc., New York.
6. Ravindera Arora and Mosch Wolfgang, 'High Voltage Insulation Engineering', New AgeInternational Publishers Limited

2nd Semester

ADVANCED PROTECTION OF POWER SYSTEM

Subject Code: MELES2-201 **L T P C** **Duration: 60 Hours**
4 0 0 4

Course Objectives: To make the students familiar to:
Numerical and digital relays.
Mathematical approach towards protection.
The development of algorithms for numerical protection.
The Application of Artificial Intelligence Based technique for digital protection.
Course Outcomes: Students will be able:
To learn the evolution of Digital Relays.
To apply Mathematical approach for numerical protection.
To develop various Protection algorithms for use in digital relays.
Learn to apply Artificial Intelligence Based Numerical Protection.

UNIT-1 (10 Hrs.)

Fundamentals: Classification of protective schemes; Overcurrent, Distance, and Differential protection, Review of basic components of a conventional protection system; Current (CT) and Voltage (VT) transformers, Relays, circuit breakers and trip circuit, Essential qualities of protection, Classification of relays based on their function, Phase and amplitude comparators. Static Comparators.
Evolution of digital relays from electromechanical relays**,** Performance and operational characteristics of digital protection**,** Recent Advances in Digital Protection of Power Systems.

UNIT-II (20 Hrs.)

Numerical Protection: Block diagram of a typical numerical relay, Advantages of numerical relays, Data acquisition system, Mathematical background to protection algorithms; Sample and first derivative (Mann and Morrison) technique, Differential equation based technique,
Discrete Fourier transform (DFT) technique; Fourier series with real and complex coefficients, Discrete Fourier Transform (DFT), Extraction of Fundamental frequency components; Full-cycle window algorithm, Half-cycle window algorithm, Computation of apparent impedance.
Walsh-Hadamard transform technique and its algorithm, Block pulse functions technique, Wavelet transform technique based algorithms**,** Numerical overcurrent protection, Numerical distance protection, and Numerical differential protection.

UNIT-III (20 Hrs.)

Microprocessor Based Numerical Protective Relays: Basic elements of digital protection; IC elements and circuits for interface, A/D converter, Analog multiplexer, Sample and Hold circuit, Their interfacing with microprocessor, Signal conditioning, the sampling theorem, signal aliasing**,** Error, Digital filtering concepts.
Digital relays: Digital relays as a unit consisting of hardware and software, digital Overcurrent relay, digital Impedance relay, digital Directional relay, digital Reactance relay, Generalized mathematical expression for distance relays, Measurement of Resistance (R) and Reactance (X), Digital Mho relay, Quadrilateral relay, Generalized interface for distance relays.

UNIT-IV (10 Hrs.)

Artificial Intelligence Based Numerical Protection: Artificial Neural Network, Fuzzy logic, Application of Artificial Intelligence to power system protection, **Application of ANN and Fuzzy Logic to:** Overcurrent protection, Transmission line protection, Power transformer protection, Generator protection, Directional relay, ANN modular approach for fault detection, classification and location.

Recommended Books:

1. Badri Ram, D N Vishwakarma, 'Power System Protection and Switchgear', Tata McGraw-Hill, 2011.
2. A.G. Phadke and J.S. Thorp, 'Computer Relaying for Power Systems', Wiley/Research Studies Press, **2009.**
3. A.T. Johns and S.K. Salman, 'Digital Protection of Power Systems', IEEE Press, 1999.
4. Gerhard Zeigler, 'Numerical Distance Protection', Siemens Publicis Corporate Publishing, 2006.
5. S.R. Bhide, 'Digital Power System Protection', PHI Learning Pvt. Ltd., 2014.
6. T.S. Madhava Rao, 'Power System Protection: Static Relays: with Microprocessor Applications', 2017.
7. B. Ravindra Nath M. Chander, 'Power System Protection and Switch Gear', John Wiley Eastern,1989.
8. Sunil S. Rao, 'Power System Protection and Switch Gear', Khanna Publishers, 1989.

POWER SYSTEM DYNAMICS & STABILITY

Subject Code: MELES2-202 **L T P C** **Duration: 60 Hours**
4 0 0 4

Course Objectives: Students will be able to:
Study of system dynamics and its physical interpretation.
Development of mathematical models for synchronous machine and induction machines.
Understand small signal and large signal stability problems, and carry out stability analysis with and without power system stabilizer (PSS).
Analyze the effect of small speed changes in synchronous machines and voltageregulator governor system, and to enhance voltage stability margin of power system.
Course Outcomes: Students will be able to:
Develop mathematical models for synchronous machine.
Develop Models of induction motor.
Understand the system dynamics and analyze the stability of dynamic systems and voltage stability problem.
Implement modern control strategies for improving stability of the power system.

UNIT-I (15 Hrs.)

Modeling of Synchronous Machines: Simplest Model of the Synchronous Machine, Equations in Physical Quantities, Inductance of Synchronous Machine, Park's Transformation to dqO components, Phasor Diagram, Equivalent Circuit and Phasor Diagram, Excitation Systems, Sub-synchronous resonance, Significance of SCR, Synchronous machine dynamics (Electromechanical transients).

UNIT-II (15 Hrs.)

Basic load modeling concepts: Static load models, Dynamic load models.
Modeling of induction motors: Equations of an induction machine, Steady-state characteristics, and Alternative rotor constructions.

UNIT-III (15 Hrs.)

Fundamental Concepts of Stability of Dynamic Systems: Stability definitions, State-space representation, Stability of dynamic system, Analysis of stability, Small signal stability of single machine infinite bus system: Generator represented by the classical model, Effects of synchronous machine field circuit dynamics.
Voltage stability: Basic concepts related to voltage stability, classification of voltage stability, Transmission system characteristics, Generator characteristics, Load characteristics, Characteristics of reactive compensating device, Multi-Machine Stability.
Voltage collapse: Typical scenario of voltage collapse, General characteristics based on actual incidents, Prevention of voltage collapse.

UNIT-IV (15 Hrs.)

Methods of Improving Stability: Automatic voltage regulator, Power system stabilizers, Active power and frequency control: Fundamental of automatic generation control, Implementation of AGC, Under frequency load shedding. Reactive power and voltage control: Production and absorption of reactive power, Method of voltage control, Shunt reactors, shunt capacitors, series capacitors, synchronous condensers, static VAR systems.

Recommended Books:

1. P. Kundur,'Power System Stability and Control'Mc GrawHill, 1994.
2. L. P. Singh, 'Adavanced power systems Analysis and Dynamics', New Age International Publishers.
3. C. W. Taylor, 'Power System Voltage Stability' McGraw Hill.
4. P. M. Anderson and A. A. Fouad,'Power System Control and Stability', IEEE Press.
5. E. Kimbark,'Power System Stability', Vol.I, II & III, IEEEPress, 2002.
6. J. Machowski, J. Bialek and J.R.W. Bumby, 'Power System Dynamics and Stability', John Wiley & Sons, **1997.**
7. L. Leonard Grigsby (Ed.), 'Power System Stability and Control', 2nd Edn., CRC Press, 2007.

SMART GRIDS

Subject Code: MELES2-203 **L T P C** **4 0 0 4** **Duration: 60 Hrs.**

Course Objectives: Students will be able to:
To understand concept of Smart Grid and its Advantages and its metering.
To understand Smart Grid technologies.
To understand about Micro grid and power quality.
To understand about communication in smart grid and distribution management system.
Course Outcomes: Students will be able to:
To describe concept of Smart Grid and its Advantages and its metering.
To describe Smart Grid technologies.
To know about Micro grid and power quality.
To describe about communication in smart grid and distribution management system.

UNIT-I (10 Hrs.)

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions and Necessity of Smart Grid, Today's Grid versus the Smart Grid, Functions of Smart Grid Components, General View of the Smart Grid Market Drive, Concept of Robust & Self-Healing grid, Present Development & International Policies in Smart Grid.

UNIT-II (20 Hrs.)

Introduction to Smart Metering: Evolution of Smart Metering, Key components of Smart metering, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.
Smart Grid Technologies: Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, Superconducting Magnetic Energy Storage (SMES), Pumped Hydro, Compressed Air Energy Storage (CAES), Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

UNIT-III (15 Hrs.)

Micro-Grid: Concept, Necessity & Applications of Micro-Grid, Formation of Micro-Grid, Issues of Interconnection, Operation, Control & Protection of Micro-Grid. Plastic & Organic solar cells, Thin film solar cells, Variable Speed Wind Generators, Fuel-cells, micro- turbines, Captive power plants, Integration of renewable energy sources.
Power Quality: Electromagnetic Compatibility (EMC) of Smart Grid, Power Quality Issues of Grid Connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT-IV (15 Hrs.)

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid, Broadband over Power line (BPL), IP based protocols, Communication through GPRS and Power Line Carrier Communication, Internet of Things (IoT) based Protocols.
Distribution Management System:-Introduction, Substation automation equipment, Faults in distribution system, Fault location & isolation and restoration, Components of fault isolation and restoration, Voltage regulation.

Recommended Books:

1. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu and Nick Jenkins, 'Smart Grid: Technology and Applications', Wiley Online Library, 2012.
2. James A. Momoh, "Smart Grid:-Fundamental of design and Analysis", IEEE Press, Wiley Publication.
3. Lars T.Berger, Krzyszt of, "Smart Grid:- Application, Communication, and Security", Wiley Publication.
4. Ali Keyhani, 'Design of Smart Power Grid Renewable Energy Systems', 2^{nd} Edn., Wiley IEEE Press.
5. Clark W. Gellings, 'The Smart Grid: Enabling Energy Efficiency and Demand Response', CRC Press, **2009**.
6. Stuart Borlase, 'Smart Grid: Infrastructure, Technology and solutions', CRC Press.

POWER SYSTEM LAB-II.

Subject Code: MELES2-204 **L T P C 0 0 4 2** **Duration: 60 Hrs.**

Course Objectives: To make the students aware about:
The various parameters that affect the output of solar panels and wind turbines.
The operation, control and protection aspects of micro-grids and the methods to enhance power quality of power system.
The smart grid technologies, metering and application of real time pricing.
The use of communication technologies for advanced metering Infrastructure.

Course Outcomes: Students will be able:
To know the various parameters affecting the solar panel output and wind turbine output.
To operate, control and protect micro-grids.
To know methods to enhance power quality of power system.
To know about smart grid technologies, metering and to apply real time pricing.
To use communication technologies for advanced metering Infrastructure.

LIST OF EXPERIMENTS

1. Power Curves.
2. Build a Wind Farm.
3. Test the Capabilities of the Hydrogen Fuel Cells and Capacitors.
4. Effect of Temperature on Solar Panel Output.
5. Variables Affecting Solar Panel Output.
6. Effect of Load on Solar Panel Output.
7. Wind Turbine Output: The Effect of Load.
8. Test the Capabilities of Solar Panels and Wind Turbines.
9. Grid integration of solar power output using power electronics interfaces.
10. Application of real time pricing in smart grids.
11. Operation, control and protection of micro-grids.
12. Power quality analysis and enhancement of power system.
13. Use of communication technologies for advanced metering Infrastructure.

POWER QUALITY

Subject Code: MELED2-211 **L T P C** **Duration: 60 Hrs.**
4 0 0 4

Course Objectives: To make the students aware about:
Review definitions and standards of common power quality phenomena.
Understand power quality monitoring and classification techniques.
Investigate different power quality phenomena causes and effects.
Understand different techniques for power quality problems mitigation.
Course Outcomes (COs): The students will be able to:
Acquire knowledge about the parameters of power quality and harmonics in power systems.
Acquire knowledge about the voltage sags and interruptions and their influence on various components.
Be able to model networks and components for power quality analysis and to apply harmonics filtering techniques.
Apply various methods for power quality monitoring.

UNIT-I (10 Hrs.)

Introduction: Definition of Electric Power Quality, Power Quality -- Voltage Quality, Power Quality Evaluation Procedure
Terms & Definitions: General Classes of Power Quality Problems, Transients, Long Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance,Waveform Distortion, Voltage Fluctuations, Power Frequency Variations, Power Quality Terms.

UNIT-II (20 Hrs.)

Voltage Sags & Interruptions: Sources of Sags and Interruptions, Estimating Voltage Sag Performance: (i) Area of Vulnerability (Weakness, Exposure), (ii) Types of Equipment Sensitivity to Voltage Sags, (iii) Transmission system sag performance evaluation, (iv) Utility distribution system sag performance evaluation, Fundamental Principles of Protection, Solutions at the End-User Level, Voltage Sag Mitigation Technologies, Motor Starting Sags: (i) Motor-starting methods, (ii) Estimating the sag severity during full-voltage starting.

UNIT-III (20 Hrs.)

Transient Over Voltages: Sources of Transient Over Voltages: (i) Capacitor switching, (ii) Magnification of capacitor-switching transients, (iii) Lightning, (iv) Ferroresonance, Principle of Over VoltageProtection, Voltage Swell Mitigation Technologies, Utility Capacitor-Switching Transients, Utility System Lightning Protection, Switching Transient Problems with Loads.
Fundamentals of Harmonics: Harmonic Distortion, Voltage Versus Current Distortion, Harmonics Versus Transients, Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Harmonic Sources from Commercial Loads, Locating Harmonic Sources, Effects of Harmonic Distortion, Harmonic Distortion Evaluations, Principles for Controlling Harmonics, Devices for Controlling Harmonic Distortions.

UNIT-IV (10 Hrs.)

Long Duration Voltage Variations: Principles of Regulating the Voltage, Devices for Voltage Regulation, Utility Voltage Regulator Application, Capacitors for Voltage Regulation, End-User Capacitor Application, , Flicker.
Power Quality Monitoring: Monitoring Considerations**,** Power Quality Measurement Equipments, Assessment ofPower Quality Measurement Data, Application of Intelligent Systems, Power Quality Monitoring Standards.

Recommended Books:

1. Roger C. Dugan, Surya Santoso, Mark F. McGranaghan, H. Wayne Beaty, 'Electrical Power Systems Quality', McGraw Hill Professional, **2002.**
2. Angelo Baggini, 'Handbook of Power Quality', Wiley, **2008**.
3. G.T. Heydt, 'Electric Power Quality', McGraw Hill Professional, **2007.**
4. Math H. Bollen, 'Understanding Power Quality Problems', IEEE Press, **2000.**
5. J. Arrillaga, 'Power System Quality Assessment', John Wiley, **2000**
6. J. Arrillaga and N. R. Watson, 'Power System Harmonics', Wiley.
7. George J. Wakileh, 'Power Systems Harmonics', Springer.

FACTS AND CUSTOM POWER DEVICES

Subject Code: MELED2-212 **L T P C 4 0 0 4** **Duration: 60 Hrs.**

Course Objectives: To make the students:
To learn the active and reactive power flow control in power system.
To understand the need for static compensators.
To develop the different control strategies used for compensation.
Course Outcomes: Students will be able to:
Acquire knowledge about the fundamentals of Reactive Power Flow Control in Power Systems.
Acquire knowledge about the fundamental principles of passive and active reactive power compensation schemes at transmission and distribution level in power systems.
Learn various Static shunt and series VAR Compensation devices.
To develop analytical modeling skills needed for modeling and analysis of such Static VAR Systems.

UNIT-I (15 Hrs.)

Reactive Power Flow Control in Power Systems: Control of dynamic power unbalances in Power System, Power flow control, Constraints of maximum transmission line loading, Benefits of FACTS Transmission line compensation, Uncompensated line shunt compensation, Series compensation, Phase angle control, Reactive power compensation, Shunt and Series compensation principles, Reactive compensation at transmission and distribution level.

UNIT-II (15 Hrs.)

Static versus passive VAR compensator, Static shunt compensators: Static VAR compensator (SVC) and Static compensator (STATCOM), Operation and control of Thyristor switched capacitor (TSC), Thyristor controlled reactor (TCR) and STATCOM, Compensator control, Comparison between SVC and STATCOM, Multilevel inverter based DSTATCOM (Distributed Static Compensator) and its applications.

UNIT-III (15 Hrs.)

Static Series Compensation: Thyristor switched series capacitor (TSSC), Static synchronous series compensator (SSSC), Static voltage and phase angle regulators, Thyristor controlled voltage regulators (TCVR) and phase angle regulators (TCPAR): Operation and Control, Applications.
Unified power flow controller (UPFC), Circuit arrangement, Operation and control of UPFC, Basic Principle of active power (P) and reactive power (Q) control, Independent real and reactive power flow control- Applications, Comparison of UPFC and UPQC (unified power quality conditioner).

UNIT-IV (15 Hrs.)

Interline power flow controller (IPFC) & FACTS: Introduction to IPFC and FACTS, Modeling and analysis of FACTS controllers, Simulation of FACTS controllers, Power quality problems in distribution systems, Comparison of various custom power devices and their applications.
Recent Trends: Application of basic active filters, multilevel and multi-pulse converters and Z-source inverter invarious FACTS and FACDS devices for improving the performances of transmission system network and distribution system network, respectively.

Recommended Books:

1. K.R. Padiyar, 'FACTS Controllers in Power Transmission and Distribution', New Age International Publishers, **2007.**

2. X.P. Zhang, C. Rehtanz, B. Pal, 'Flexible AC Transmission Systems- Modelling and Control', Springer Verlag, Berlin, **2006.**
3. N.G. Hingorani, L. Gyugyi, 'Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems', IEEE Press Book, Standard Publishers and Distributors, Delhi, **2001**.
4. K.S. Sureshkumar, S. Ashok, 'FACTS Controllers & Applications', e-book Edn., Nalanda Digital Library, NIT Calicut, **2003.**
5. Y.H. Song and A.T. Johns, 'Flexible AC Transmission Systems', IEEE Press, **1999**.
6. R.M. Mathur and R.K. Verma, 'Thyristor based FACTS controllers for Electrical TransmissionSystems', IEEE Press, **2002**.

DIGITAL TRANSFORMATION IN INDUSTRY

Subject Code: MELED2-213 **L T P C** **4 0 0 4** **Duration: 60 Hours**

Course Objectives: To make the students to:
To learn about Industry 4.0 and its foundation for the digital transformation term
To understand the concepts of digital supply chains and smart factory.
Learn basics of block chain technology and its application for crypto currency.
To acquire knowledge about real cases from different industries to know that how industries are evolving with the changes and to learn how to overcome the challenges of digital transformation projects.

Course outcomes: The students will be able:
To review the basic concepts about Industry 4.0 and its foundation for the digital transformation term.
To understand digital supply chains and smartly operate a factory.
To understand block chain technology and its application for crypto currency.
To acquire knowledge to learn to overcome the challenges of digital transformation projects.

UNIT-1 (12 Hrs.)

Introduction: Introduction to Industry 4.0, History of Industry 4.0, Industry 4.0 terminologies definition, Industrial Internet, First stages of maturity, The next maturity stages, Society 5.0, Society 5.0: breaking down 5 walls, The Various Industrial Revolutions: Evolution of Industrial Revolutions, INDUSTRY 4.0 - Drivers, Enablers, Challenges and Benefits.

UNIT-II (18 Hrs.)

Smart Factory: Traditional Supply Chains, Digital Supply Chains and Smart Factory, Characteristics of Smart Factory: Connected, Optimized, Transparency, Proactive, Agile
Introduction to Cloud technology, IoT and overview of deployment models (SaaS, PaaS, IaaS), Introduction to Horizontal and Vertical Integration
Digital Twin: Computer Simulation, Introduction to Augmented reality (AR), Virtual reality (VR) and Mixed Reality (MR) and Comparison of AR, VR and MR.
Role of Artificial intelligence & Machine learning in Industry 4.0.

UNIT-III (15 Hrs.)

Block Chain: Overview, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public v/s Private Block chain, Basic crypto currency, Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block chain, Basic Crypto Primitives: Cryptographic Hash Function and its Properties, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography.
Understanding Crypto Currency with Block Chain: Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and
block relay, Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW).

UNIT-IV (15 Hrs.)

Digital Transformation: Introduction, Digital business transformation, Causes of disruption and transformation, Digital transformation myths and realities, Digital Transformation and customer experience, 4 pillars in customer experience transformation; IT uplift, Digitizing operations, Digital marketing and Digital businesses. -
Applications of Digital transformation:
Applications of Digital transformation across various industries, Retail industry, Government and the public sector, Insurance industry, Healthcare, Banking: Royal Bank of Scotland case study,

Fintech: Travelex case study, Public Sector: The MET office case study.

Recommended Books:

1. Srinivas R Pangali, Shankar Prakash, Jyothi R Korem, 'Digital Transformation Strategies', Sage publications, 2021
2. Thomas M Siebel, 'Digital Transformation', Rosettabooks, 2019.
3. Antony Lewis, 'The Basics of Bitcoins and Blockchain', Mango Media Incorporation, 2018.

RENEWABLE ENERGY SYSTEM AND DISTRIBUTED GENERATION

Subject Code: MELED2-221 **L T P C 4 0 0 4** **Duration: 60 Hours**

Course Objectives: Students will be able to:
To learn various renewable energy sources.
To gain understanding of integrated operation of renewable energy sources.
To understand Power Electronics Interface with the Grid.
To understand about Distributed Generation.
Course Outcomes: Students will be able to:
Know about various renewable energy sources, especially solar and wind energy in detail.
Know that how to tap hydro energy and energy from biomass.
Know the means and methods to harness energy from tides, waves, and geothermal energy as well as working of fuel cells.
Know the distributed generation system in autonomous/grid connected modes and its impact on Power System.

UNIT-I (15 Hrs.)

Introduction to Renewable Energy Resources: World Energy Future, Conventional Energy Sources, Non-Conventional Energy Sources, Prospects of Renewable Energy Sources, Types, Advantages, Limitations & scope of renewable energy resources.
Solar Energy: Introduction to Solar Radiation and its measurement, Introduction to Solar Energy Collectors and Storage, Solar Electric Power Generation, Solar Photo-Voltaic, Solar Cell Principle, Semiconductor Junctions, Conversion efficiency and power output, Basic Photovoltaic System for Power Generation.
Wind Energy: Introduction to Wind Energy Conversion (WEC), Wind data and energy estimation, Site selection considerations, Basic Components of a Wind Energy Conversion System, Classification of WEC Systems, Schemes for Electric Generation using Synchronous Generator and Induction Generator, Wind energy Storage.

UNIT-II (15 Hrs.)

Hydro Energy: Site selection, Types of power stations, Major components & their working.
Biomass Energy: Biomass conversion technologies, photosynthesis, Bio-gas generation, types of bio-gas plants, Biomass as a Source of Energy: Method for obtaining energy from Bio-mass, Biological Conversion of Solar Energy.

UNIT-III (15 Hrs.)

Tidal Energy: Basic principles of tidal energy, Tidal power generation systems.
Wave Energy: Wave energy conversion devices, Advantages and Disadvantages of wave energy.
Geothermal Energy: Origin and nature of geothermal energy; Classification of geothermal resources; Schematic of geothermal power plants.
Fuel Cells: Schematic of fuel cell, Characteristics, Working of different types of fuel cells.

UNIT-IV (15 Hrs.)

Distributed Generation: Introduction, Distributed v/s central station generation, Technologies of distributed generation as sources of energy such as Micro-turbines, Micro combined heat power, Rooftop solar PV, Solar and wind hybrid system, Impact of distributed generation on power grid reliability.
Distributed Generators: Introduction, Various types of distributed generators, such as, Permanent magnet generator, Self-excited Induction generators, Power Electronic Interface of distributed Generators with the Grid, Analysis of Effect of Distributed Generation on Transmission System Operation, Protection of Distributed Generators, Economics Issues of Distributed Generation, Case Studies on distributed generations for electric vehicle and energy storage

integration.

Recommended Books:

1. D.P. Kothari, K.C. Singal and Ranjan Rakesh, 'Renewable Energy Sources and Emerging Technologies', 2nd Edn., Prentice Hall of India, **2011**.
2. Math H. Bollen, Fainan Hassan, 'Integration of Distributed Generation in the Power System', Wiley-IEEE Press, **2011**.
3. Loi Lei Lai, Tze Fun Chan, 'Distributed Generation: Induction and Permanent Magnet Generators', Wiley-IEEE Press, **2007**.
4. A.Roger, Messenger and Jerry Ventre, 'Photovoltaic System Engineering', 3rd Edn., **2010.**
5. James F. Manwell, Jon G. McGowan and Anthony L. Rogers, 'Wind Energy Explained: Theory Design and Application', 2nd Edn., John Wiley and Sons **2010**.
6. G.D. Rai, 'Non-Conventional Sources of Energy', Khanna Publishers.
7. David Boyles, 'Bio Energy', Elis Horwood Ltd.
8. N.K. Bansal and M. Kleemann, M. Heliss, 'Renewable Energy Sources and Conversion Technology', Tata McGraw Hill, **1990**.
9. O.P. Vimal and P.D. Tyagi, 'Bio Energy Spectrum', Bio Energy and Wasteland DevelopmentOrganization.

SCADA SYSTEM AND APPLICATIONS

Subject Code: MELED2-222 **L T P C** **Duration: 60 Hrs.**
4 0 0 4

Course Objectives: To make the students to get insight into the:
Basic architecture and components of SCADA.
Functions and communication in SCADA.
Applications of SCADA.
Course Outcomes: Students will be able to:
Describe the basic tasks of supervisory control and data acquisition systems (SCADA) as well as their typical applications.
Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.
Knowledge about single unified standard architecture IEC 61850.
To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

UNIT-I (15 Hrs.)

Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Building blocks of SCADA systems, SCADA System Components, Classification of SCADA systems, Communication technologies, Monitoring and supervisory functions, SCADA applications in Industries and Utility Automation.

UNIT-II (15 Hrs.)

Remote Terminal Unit (RTU) and its components, Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Logic subsystem, Termination subsystem, Testing and human-machine interface (HMI) subsystem, Power supplies, Advanced RTU functionalities, Data concentrators and merging units, Master Station: Master station software components, Master station hardware components, SCADA Server, SCADA/HMI Systems, Server systems in the master station, Global positioning systems (GPS), Master station performance.

UNIT-III (15 Hrs.)

SCADA Architecture, Various SCADA architectures, advantages and disadvantages of each system, Single unified standard architecture -IEC 61850.
SCADA Communication, Communication Network, Communication subsystem, various industrial communication technologies, wired and wireless methods and fiber optics, Open standard communication protocols, comparison with wide area monitoring system (WAMS).

UNIT-IV (15 Hrs.)

SCADA Applications: Utility applications, Transmission and distribution sector operations, monitoring, analysis and improvement, Situational awareness, Intelligent alarm filtering: Need and technique, Alarm suppression techniques, Operator needs and requirements, Industries - oil, gas and water, Case studies, Implementation, Simulation exercises.

Recommended Books:
1. Stuart A. Boyer, 'SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications, USA, 2004.
2. Gordon Clarke, Deon Reynders, 'Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems', Newnes Publications, Oxford, UK, 2004.
3. William T. Shaw, 'Cyber-security for SCADA Systems', Penn Well Books, 2006.

4. David Bailey, Edwin Wright, 'Practical SCADA for Industry', Newnes, 2003.
5. Michael Wiebe, 'A Guide to Utility Automation: AMR, SCADA, and IT Systems for Electric Power', Penn Well Books, 1999.
6. Bela G. Liptak, Halit Eren, 'Instrument Engineers Process Software and Digital Networks', 4th Edn., Vol.-3, 2016.

OPTIMIZATION TECHNIQUES FOR POWER ENGINEERING

Subject Code: MELED2-223 **L T P C 4 0 0 4** **Duration: 60 Hrs.**

Course Objectives: - To introduce the students:
To learn about basics of optimization and essential optimization techniques for applying to day to day problems.
To learn about linear and non-linear programming problems and apply the methods for solving these problems in various fields of engg. and technology.
To acquaint them with unconstrained and constrained multivariable optimization nonlinear programming problems.
To non-conventional optimization methods such as, Genetic Algorithm, Particle swarm optimization etc. and their applications in power system.
Course Outcomes: Students will be able:
To gain knowledge about basics of optimization.
To apply linear and non-linear programming for solving problems in various fields of Engg. and Tech.
To acquire skills to solve unconstrained and constrained multivariable optimization nonlinear programming problems.
To apply non-conventional optimization methods such as Simulated annealing method, Genetic Algorithm, Particle swarm optimization etc.

UNIT-I (10 Hrs.)

Introduction to Optimization: Statement of an optimization problem, Classification of optimization problems, Classical Optimization techniques, Single variable optimization, Multivariable optimization, Optimization with and without inequality constraints, Single objective and multi objective optimization, Engineering applications of optimization.

UNIT-II (20 Hrs.)

Linear Programming (LP): Standard form of linear programming, Simplex method, Revised simplex method, Computer implementation of the Simplex method, Duality theory, Constrained Optimization, Theorems and procedure, linear programming, mathematical model, solution technique, duality.
Non-Linear Programming (NLP): One–Dimensional Minimization Methods: Unimodal function, Dichotomous search, Fibonacci search, Golden Section, Cubic interpolation method, Direct root, Newton Raphson Method.
Transportation Problem: North-West Corner rule, least cost method, Vogel approximation method, testing for optimality.

UNIT-III (15 Hrs.)

Unconstrained Multivariable Optimization Techniques: Random search method, Steepest descent method, Conjugate gradient method, Sequential quadratic programming, Newton Raphson Method, Evolutionary search, Hooke-Jeeves Method, Simplex search Method.
Constrained Optimization Techniques: Interior Penalty function method, Exterior penalty function method, Method of Multipliers, KKT Conditions.
Dynamic Programming (DP): Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm.

UNIT-IV (15 Hrs.)

Further Topics in Optimization: Critical path method (CPM), Program evaluation and review technique (PERT), Multi-objective Optimization Techniques, Weighting method, ε- constraint method, Genetic Algorithm, Particle swarm optimization.

Genetic Algorithm (GA): Introduction to Genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between GA and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded GA, Advanced GA, Applications to power system.

Recommended Books:

1. S.S. Rao, 'Optimization: Theory and Application', Wiley Eastern Press, 2nd Edn., **1984**.
2. Deb Kalyanmoy, 'Optimisation for Engineering Design - Algorithms and Examples', Prentice Hall India, **1998.**
3. H.A. Taha, 'Operations Research - An Introduction', Prentice Hall of India, **2003**.
4. R.L. Fox, 'Optimization Methods for Engineering Design', Addition Welsey, **1971**.

A. Ravindran, K.M. Ragsdell and G.V. Reklaitis, 'Engineering Optimization: Methods and Applications', Wiley, **2008**.

5. Godfrey C. Onwubolu, B.V. Babu, 'New Optimization Techniques in Engineering', Springer, **2004**.
6. D.P. Kothari & J.S. Dhillon, 'Power System Optimization', Prentice-Hall of India, **2010**.

3rd & 4th Semester

PROJECT

Subject Code: MELES2-301 **L T P C**
0 0 6 3

The object of Project is to enable the student to take up investigative study in the broad field of Electrical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis under the guidance of a supervisor from the department alone or jointly with a supervisor drawn from R&D laboratory/Industry. This is expected to provide a good initiation for the student in R&D work. The assignment to normally include:

Survey and study of published literature on the assigned topic.

Define the objective, formulate the problem and prepare an action plan for conducting the investigation.

Then perform the required Experiment/Develop a Simulation Model/Solve the Problem/Develop a Design/Explore the feasibility/Conduct a survey etc. depending upon the action plan.

Analyze the results and prepare a written report on the study conducted for presentation to the Department.

Final seminar, as oral presentation before a departmental committee.

SEMINAR

Subject Code: MELES2-302 **L T P C**
0 0 2 1

Course Objectives:
To identify, understand and discuss current advanced research topics.
To gain experience in the critical assessment of the available scientific literature
To practice the use of various resources to locate and extract information using offline & online tools, journals
Course Outcomes:
An ability to utilize technical resources
An ability to write technical documents and give oral presentations related to the workcompleted.
To learn preparation and presentation of scientific papers in an exhaustive manner
Each student will be required to prepare a Seminar Report and present a Seminar on a topic in anyof the areas of modern technology related to Electrical Engineering including interdisciplinary fields.
NOTE: Seminar will carry 1 credit. It will be done on any topic within/outside the curriculum. Its evaluation will be done as under:

Sr. No.	Parameters for Evaluation	Internal Marks	External Marks
1	Depth & Coverage of Topic	40	-
2	PPT Presentation & Report	20	-
3	Presentation	20	-
4	Questions & Answers	20	-
Total		**100**	**-**

RESEARCH METHODOLOGY AND IPR

Subject Code - MREMI0-101	LTPC 4 0 0 4	Duration-60 hrs

Course Objectives: To make the students to:

1. Understand that how to formulate a research problem, analyze research related information, follow research ethics, and to design experiments.
2. To learn to collect or sample data, process it and validate results etc.
3. Do effective literature studies and develop a research proposal.
4. Understand the need of information about Intellectual Property Right (IPR) in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D.

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

1. Formulate a research problem, analyze research related information, and follow research ethics and design experiments.
2. Collect, sample, scale, validate and process data.
3. To do literature survey effectively and develop a good research proposal.
4. Motivated to do research work and invest in R & D to create new and better products for economic growth and social benefits.

UNIT-I (15 Hrs.)

Research Problem: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problems, Data collection, Analysis, Interpretation, Necessary instrumentation.

Design of Experiment: Basic Principal of Experimental Design, Randomized Block, Completely Randomized Block, Latin Square, Factorial Design.

Hypothesis: Types, Formulation of Hypothesis, Feasibility, Preparation and Presentation of Research Proposal.

UNIT-II (15 Hrs.)

Sources of Data: Primary and Secondary, Validation of Data

Data Collection Methods: Questionnaire Designing, Construction

Sampling Design & Techniques – Probability Sampling and Non Probability Sampling.

Scaling Techniques: Meaning & Types.

Reliability: Test–Retest Reliability, Alternative Form Reliability, Internal Comparison Reliability and Scorer Reliability.

Validity: Content Validity, Criterion Related Validity and Construct Validity.

Data Process Operations: Editing, Sorting, Coding, Classification and Tabulation.

UNIT-III (10 Hrs.)

Literature Survey: Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Literature Review: Need of review - Guidelines for review - Record of research review.

Effective Literature Studies Approaches: Analysis Plagiarism, Research ethics, Effective technical writing, Essentials of report writing, Report Format, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT-IV (20 Hrs.)

Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: Technological research, Innovation, Patenting, development, Introduction to international Scenario on Intellectual Property, Procedure for grants of patents, Patenting under PCT.

Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information

and databases, Introduction to patent searching and World Intellectual Property Organization (WIPO).
New Developments in IPR: Administration of Patent System. New developments in IPR: introduction to IPR of Biological Systems, Computer Software etc. Traditional Knowledge Case Studies, IPR or IITs.

Recommended Books:

1. Stuart Melville and Wayne Goddard, 'Research Methodology: An Introduction for Science & Engineering Students', Juta & Co. Ltd., 1996.
2. Ranjit Kumar, 2nd Edn., 'Research Methodology: A Step by Step Guide for Beginners'.
3. C.R Kothari, "Research Methodology, Methods & Techniques", New Age International Publishers, New Delhi, 2004.
4. R. Ganesan, 'Research Methodology for Engineers', MJP Publishers, Chennai, 2011.
5. Ratan Khananabis and Suvasis Saha, "Research Methodology", Universities Press, Hyderabad, 2015.
6. Vijay Upagade and Aravind Shende, 'Research Methodology', S. Chand & Company Ltd., New Delhi, 2009.
7. G. Nageswara Rao, 'Research Methodology and Quantitative methods', BS Publications, Hyderabad, 2012.
8. Debora J. Halbert, 'Resisting Intellectual Property', Taylor & Francis Ltd., 2005, DOI https://doi.org/10.4324/9780203799512.
9. Robert P. Merges, Peter S. Menell, Mark A. Lemley, 'Intellectual Property in New Technological Age', 2016.
10. T. Ramappa, 'Intellectual Property Rights Under WTO', S. Chand, 2008.