1st Semester		Contact Hrs.			Marks			Credits
Code	**Course**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MELEE1-101	Power System Analysis	3	0	0	40	60	100	3
MELEE1-102	Power System Dynamics-I	3	0	0	40	60	100	3
MRMIP-101	Research Methodology and IPR	2	0	0	40	60	100	2
MELEE1-103	Power System (Power System Steady State Analysis) Lab-I.	0	0	4	60	40	100	2
MELEE1-104	Power System (Renewable Energy) Lab-II.	0	0	4	60	40	100	2
Departmental Elective-I		3	0	0	40	60	100	3
MELEE1-156	Renewable Energy System and Distributed Generation							
MELEE1-157	Smart Grids							
MELEE1-158	High Power Converters							
MELEE1-159	Wind and Solar Systems							
Departmental Elective-II		3	0	0	40	60	100	3
MELEE1-160	Electrical Power Distribution System							
MELEE1-161	Optimization Techniques for Power Engineering							
MELEE1-162	Pulse Width Modulation for PE Converters							
MELEE1-163	Electric and Hybrid Vehicles							
Audit Course (Choose any one)		2	0	0	100	0	100	0
MHUMA0-101	English For Research Paper Writing							
MCIVE0-101	Disaster Management							
MHUMA0-102	Sanskrit for Technical Knowledge							
MHUMA0-103	Value Education							
MHUMA0-104	Constitution of India							
MHUMA0-105	Pedagogy Studies							
MHUMA0-106	Stress Management by Yoga							
MHUMA0-107	Personality Development through Life Enlightenment Skills							
Total		**16**	**0**	**8**	**420**	**380**	**800**	**18**

Programme Outcomes of Power Systems Stream:

PO1: Ability to apply the enhanced knowledge in advanced technologies for modeling, analyzing and solving contemporary issues in power sector with a global perspective.
PO2: Ability to critically analyze and carry out detailed investigation on multifaceted complex Problems in area of Power Systems and envisage advanced research in thrust areas.
PO3: Ability to identify, analyze and solve real-life engineering problems in the area of Power Systems and provide strategic solutions satisfying the safety, cultural, societal and environmental aspects/ needs.
PO4: Ability for continued pursuance of research and to design, develop and propose theoretical and practical methodologies towards research and development support for the Power System infrastructure.
PO5: Ability to develop and utilize modern tools for modeling, analyzing and solving various Engineering problems related to Power Systems.
PO6: Willingness and ability to work in a team of engineers/ researchers with mutual understandings to take unsophisticated challenges, in the field of Power Systems, lead and motivate the group to inculcate multi-disciplinary and collaborative approach.PO7 Willingness and ability to take up administrative challenges including the management of various projects of interdisciplinary nature and carry out the same in an efficient manner giving due consideration to societal, environmental, economic and financial factors.
PO8: Ability to express ideas clearly and communicate orally as well as in writing with others in an effective manner, adhering to various national and international standards and practices for the documentation and presentation of the contents.

POWER SYSTEM ANALYSIS

Subject Code: MELEE1-101 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: Students will be able to:
1. Study various methods of load flow and their advantages and disadvantages.
2. Understand how to analyze various types of faults in power system.
3. Understand power system security concepts and study the methods to rank the contingencies.
4. Understand need of state estimation and study simple algorithms for state estimation.
5. Study voltage instability phenomenon.

UNIT-I (8 Hrs.)

Load Flow: Overview of Newton-Raphson, Gauss-Siedel, Fast decoupled methods, convergence properties, sparsity techniques, handling Q- max violations in constant matrix, inclusion of frequency effects. AVR in load flow, handling of discrete variables in load flow.

UNIT-II (8 Hrs.)

Fault Analysis: Simultaneous faults, open conductor faults. Generalized method of fault analysis.

UNIT-III (8 Hrs.)

Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, Overload index ranking.

UNIT-IV (8 Hrs.)

State Estimation: Sources of errors in measurement, Virtual and pseudo measurement, Observability, Tracking state estimation. WSL method, bad data correction.

UNIT-V (8 Hrs.)

Voltage Stability: Voltage collapse, P-V curve, optimal power flow solution, continuation power flow, voltage collapse proximity indices.

Recommended Books:
1. J.J. Grainger and W.D. Stevenson, 'Power System Analysis', McGraw Hill, **2003**.
2. R. Bergen and Vijay Vittal, 'Power System Analysis', Pearson, **2000**.
3. L.P. Singh, 'Advanced Power System Analysis and Dynamics', New Age International, **2006**.
4. G.L. Kusic, 'Computer aided Power System Analysis', Prentice Hall India, **1986**.
5. A.J. Wood, 'Power Generation, Operation and Control', John Wiley, **1994.**
6. P.M. Anderson, 'Faulted Power System Analysis', IEEE Press, **1995**.

Course Outcomes: Students will be able to:
1. Able to calculate voltage phasor at all buses, given the data using various methods of load flow.
2. Able to calculate fault currents in each phase.
3. Rank various contingencies according to their severity.
4. Estimate the bus voltage phasor given various quantities viz. power flow, voltages, taps, CB status etc.
5. Estimate closeness to voltage collapse and calculate PV curves using continuation power flow.

POWER SYSTEM DYNAMICS-I

Subject Code: MELEE1-102 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: Students will be able to:
1. Study of system dynamics and its physical interpretation.
2. Development of mathematical models for synchronous machine.
3. Modelling of induction motor.

UNIT-I (10 Hrs.)

Synchronous Machines: Per unit systems, Park's Transformation (modified), Flux-linkage equations, power angle characteristics during steady state and transient state, Significance of SCR.

UNIT-II (8 Hrs.)

Voltage and current equations, torque equation, Formulation of State-space equations, Equivalent circuit.

UNIT-III (8 Hrs.)

Sub-transient and transient inductance and Time constants, Simplified models of synchronous machines, synchronous machine dynamics (Electromechanical transients).

UNIT-IV (8 Hrs.)

Small Signal Model: Introduction to frequency model, Excitation systems and Philips-Heffron model, Power System Stabilizer Load modeling.

UNIT-V (6 Hrs.)

Modeling of Induction Motors: Prime mover controllers, Induction motor dynamics during starting and breaking.

Recommended Books:

1. P.M. Anderson & A.A. Fouad, 'Power System Control and Stability', Galgotia, New Delhi, **1981.**
2. J. Machowski, J. Bialek and J.R.W. Bumby, 'Power System Dynamics and Stability', John Wiley & Sons, **1997.**
3. P. Kundur, 'Power System Stability and Control', McGraw Hill Inc.,**1994**.
4. E.W. Kimbark, 'Power System Stability', Vol.-I & III, John Wiley & Sons, New York, **2002**.

Course Outcomes: Students will be able to:
1. Understand the modeling of synchronous machine in details.
2. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI POWER.
3. Carry out stability analysis with and without power system stabilizer (PSS).
4. Understand the load modelling in power system.

RESEARCH METHODOLOGY AND IPR

Subject Code: MRMIP0-101 **L T P C** **Duration: 28 Hrs.**
2 0 0 2

Course Objectives:
To learn the fundamentals of Operating Systems and gain knowledge on Distributed operating system concepts that includes architecture, Mutual exclusion algorithms, Deadlock detection algorithms and agreement protocols

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

CO1: Understand research problem formulation, analyze research related information, Follow research ethics

CO2: Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
CO3: Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
CO4: Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT-I (7 Hrs.)

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 problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT-II (7 Hrs.)

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT-III (7 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.

UNIT-IV (7 Hrs.)

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases.
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'.
2. Wayne Goddard and Stuart Melville, 'Research Methodology: An Introduction'.
3. Ranjit Kumar, 2nd Edn., 'Research Methodology: A Step by Step Guide for Beginners'.
4. Halbert, 'Resisting Intellectual Property', Taylor & Francis Ltd., **2007**.
5. Mayall , 'Industrial Design', McGraw Hill, **1992**.
6. Niebel , 'Product Design', McGraw Hill, **1974**.
7. Asimov, 'Introduction to Design', Prentice Hall, **1962**.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, 'Intellectual Property in New Technological Age', **2016**.
9. T. Ramappa, 'Intellectual Property Rights Under WTO', S. Chand, **2008.**

POWER SYSTEM (POWER SYSTEM STEADY STATE ANALYSIS) LAB-I.

Subject Code: MELEE1-103 **L T P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Simulation of IGBT Inverters.
2. Simulation of Thyristor Converters.
3. Transient Stability Studies.
4. Short Circuit Studies.

5. Load Flow and optimal load flow Studies.
6. Load Flow and optimal load flow Studies.
7. Simulation of automatic generation control.

POWER SYSTEM (RENEWABLE ENERGY) LAB-II.

Subject Code: MELEE1-104 **L T P C**
0 0 4 2

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.

RENEWABLE ENERGY SYSTEM & DISTRIBUTED GENERATION

Subject Code: MELEE1-156 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: Students will be able to:
1. To learn various renewable energy sources.
2. To gain understanding of integrated operation of renewable energy sources.
3. To understand Power Electronics Interface with the Grid.
4. To understand about Distributed Generation.

UNIT-I (8 Hrs.)

Introduction to Renewable Energy Resources: Types, Advantages, Limitations & scope of renewable energy resources.
Solar Energy: Basic principles and energy conversion schemes.
Wind Energy: Introduction, Basic principles & energy conversion schemes, Major components, Electrical wind generators and their analysis.

UNIT-II (4 Hrs.)

Hydro Energy: Site selection, Types of power stations, Major components & their working.
Biomass Energy: Biogas generation, Types of biogas plants.

UNIT-III (8 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 (10 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.

UNIT-V (10 Hrs.)

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**.

Course Outcomes: Students will be able to:

1. Know about various renewable energy sources.
2. Understand the working of distributed generation system in autonomous/grid connected modes.
3. Know the Impact of Distributed Generation on Power System.

SMART GRIDS

Subject Code: MELEE1-157 | **L T P C** **3 0 0 3** | **Duration: 40 Hrs.**

Course Objectives: Students will be able to:

1. Understand concept of Smart Grid and its Advantages over Conventional Grid.
2. Know Smart Metering Techniques.
3. Learn wide area measurement techniques.
4. Understanding the problems associated with integration of distributed generation & its solution through smart grid.

UNIT-I (7 Hrs.)

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions and Necessity of Smart Grid, Concept of Robust & Self-Healing Grid, Present Development & International Policies in Smart Grid.

UNIT-II (7 Hrs.)

Introduction to Smart Meters: 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.

UNIT-III (7 Hrs.)

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-IV (7 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.

UNIT-V (6 Hrs.)

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-VI (6 Hrs.)

Communications in Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network, Communication through GPRS and Power Line Carrier Communication, Internet of Things (IoT) based Protocols.

Recommended Books:

1. Ali Keyhani, 'Design of Smart Power Grid Renewable Energy Systems', 2nd Edn., Wiley IEEE Press.
2. Clark W. Gellings, 'The Smart Grid: Enabling Energy Efficiency and Demand Response', CRC Press, **2009**.
3. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu and Nick Jenkins, 'Smart Grid: Technology and Applications', Wiley Online Library, **2012**.
4. Stuart Borlase, 'Smart Grid: Infrastructure, Technology and solutions', CRC Press.

Course Outcomes:

Students will be able to:

1. Appreciate the difference between Smart grid & Conventional grid.
2. Apply smart metering concepts to industrial and Commercial Installations.
3. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements.
4. Come up with smart grid solutions using modern communication technologies.

HIGH POWER CONVERTERS

Subject Code: MELEE1-158 | **L T P C** **3 0 0 3** | **Duration: 40 Hrs.**

Course Objectives: Students will be able to:

1. Understand the requirements of high power rated converters.
2. Understand the different topologies involved for these converters.
3. Able to understand the design of protection circuits for these converters.

UNIT-I (8 Hrs.)

Power Electronic Systems: Power semiconductors devices and circuits, Characteristics and specification of switches, Phase shifting transformer.

Multi-Pulse Diode Rectifier: Multiphase star rectifier, three phase bridge rectifier, three phase bridge rectifier with RL load, three phase rectifier with a highly inductive load, Rectifier circuit design, output voltage with LC filter.

UNIT-II (6 Hrs.)

Multi-Pulse SCR Rectifier: Three-phase full converters with *RL* load, Twelve –pulse converters, Effect of load and source inductance.

UNIT-III (8 Hrs.)

Multilevel Inverters: Introduction, Multilevel concept, Types of multilevel inverters such as: diode clamped multilevel inverter, Flying-Capacitor multilevel inverter, Cascaded multilevel inverter, Applications, PWM current source inverters.

UNIT-IV (4 Hrs.)

DC-DC Converter: Introduction, performance parameter of DC-DC converters, Switching mode regulators such as: Buck, Boost and Buck-Boost regulators.

UNIT-V (8 Hrs.)

AC Voltage Controllers: Introduction, performance parameters of AC voltage controllers, single phase full wave controller with resistive loads and inductive loads, three phase full wave controllers, three phase full wave delta connected controllers, Single phase and three phase Cyclo-converters, Matrix converter.

Un-interruptible Power Supply (UPS): Switched mode DC and AC power supplies.

UNIT-VI (6 Hrs.)

Protection of Devices and Circuits: Introduction, Cooling and heat sinks, Thermal modeling of power switching devices, Snubber circuit, Reverse recovery transients, supply and load side transients, Voltage protection by selenium diodes and metal oxide varistors, Current protections, fusing, fault current with AC & DC source.

Recommended Books:

1. N. Mohan, T.M. Undeland and W.P. Robbins, 'Power Electronics: Converter, Applications and Design', John Wiley and Sons, **1989.**
2. P.S. Bhimbra, 'Power Electronics', Khanna Publishers, **2012.**
3. M.H. Rashid, 'Power Electronics', Pearson/Prentice Hall, **2004.**
4. B.K. Bose, 'Power Electronics and A.C. Drives', Prentice Hall, **1986.**
5. Bin Wu, 'High Power Converters and Drives', IEEE Press, Wiley Interscience.

Course Outcomes: Students will be able to:

1. Learn the characteristics of PSDs such as SCRs, GTOs, IGBTs and use them in practical systems.
2. Knowledge of working of multi-level VSIs, DC-DC switched mode converters, Cyclo-converters and PWM techniques and the ability to use them properly.
3. Acquire knowledge of power conditioners and their applications.
4. Ability to design power circuit and protection circuit of PSDs and converters.

WIND AND SOLAR SYSTEMS

Subject Code: MELEE1-159 | **L T P C 3 0 0 3** | **Duration: 40 Hrs.**

Course Objectives: Students will be able to:

1. To get exposure to wind and solar systems.
2. To understand the factors involved in installation and commissioning of a Solar or Wind plant.
3. Learning the dynamics involved when interconnected with power system grid.

UNIT-I (7 Hrs.)

Historical development and current status, characteristics of wind power generation, network integration issues.

UNIT-II (7 Hrs.)

Generators and power electronics for wind turbines, power quality standards for wind turbines, Technical regulations for interconnections of wind farm with power systems.

UNIT-III (7 Hrs.)

Isolated wind systems, reactive power and voltage control, Economic aspects.

UNIT-IV (7 Hrs.)

Impacts on power system dynamics, power system interconnection.

UNIT-V (6 Hrs.)

Introduction of solar systems, Merits and demerits, concentrators, various applications.

UNIT-VI (6 Hrs.)

Solar thermal power generation, PV power generation, Energy Storage device, Designing the solar system for small installations.

Recommended Books:

1. Thomas Ackermann, Editor, 'Wind Power in Power Systems', John Willy and Sons Ltd, , **2005**.
2. Siegfried Heier, 'Grid Integration of Wind Energy Conversion Systems', John Willy and Sons Ltd., **2006**.
3. K. Sukhatme and S.P. Sukhatme, 'Solar Energy', Tata McGraw Hill, 2nd Edn., **1996.**

Course Outcomes: Students will be able to:

1. Appreciate the importance of energy growth of the power generation from the renewable energy sources and participate in solving these problems.
2. Demonstrate the knowledge of the physics of wind power and solar power generation and all associated issues so as to solve practical problems.
3. Demonstrate the knowledge of physics of solar power generation and the associated issues Identify, formulate and solve the problems of energy crises using wind and solar energy.

ELECTRIC POWER DISTRIBUTION SYSTEM

Subject Code: MELEE1-160 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: Students will be able to:

1. Learning about power distribution system.
2. Learning of SCADA System.
3. Understanding Distribution Automation.

UNIT-I (8 Hrs.)

Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long-term, Power system loading, Technological forecasting.

UNIT-II (8 Hrs.)

Advantages of Distribution Management System (D.M.S.) Distribution Automation: Definition, Restoration/Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction.

UNIT-III (8 Hrs.)

Interconnection of Distribution, Control & Communication Systems, Remote Metering, Smart meter and Automatic Meter Reading and its implementation.

UNIT-IV (8 Hrs.)

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-V (8 Hrs.)

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.

Recommended Books:

1. A.S. Pabla, 'Electric Power Distribution', 4th Edn., Tata McGraw Hill Publishing Co. Ltd.
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.

Course Outcomes: Students will be able to:
1. Understand of power distribution system.
2. Study of Distribution automation and its application in practice.
3. To learn SCADA system.

OPTIMIZATION TECHNIQUES FOR POWER ENGINEERING

Subject Code: MELEE1-161 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: -Students will be able to:
1. To understand the relevance of mathematical methods to solve engineering problems.
2. To understand how to apply these methods for a given engineering problem.

UNIT-I (4 Hrs.)

Introduction to Optimization: Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engineering applications of optimization, Single variable optimization, Multivariable optimization with no constraints.

UNIT-II (6 Hrs.)

Linear Programming: Standard form of linear programming, Simplex method, Computer implementation of the Simplex method, Duality theory.

Transportation Problem: North-West Corner rule, least cost method, Vogel approximation method, testing for optimality.

UNIT-III (7 Hrs.)

Non-Linear Programming: One–Dimensional Minimization Methods: Unimodal function, Dichotomous search, Fibonacci search, Golden Section, Cubic interpolation method, Direct root, Newton Raphson Method.

UNIT-IV (7 Hrs.)

Unconstrained Multivariable Optimization Techniques: Random search method, Steepest descent method, Conjugate gradient method, Newton Raphson Method, Evolutionary search, Hooke-Jeeves Method, Simplex search Method.

UNIT-V (8 Hrs.)

Constrained Optimization Techniques: Interior Penalty function method, Exterior penalty function method, Method of Multipliers, KKT Conditions.

UNIT-VI (8 Hrs.)

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

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**.
5. A. Ravindran, K.M. Ragsdell and G.V. Reklaitis, ‘Engineering Optimization: Methods and Applications’, Wiley, **2008**.
6. Godfrey C. Onwubolu, B.V. Babu, ‘New Optimization Techniques in Engineering’, Springer, **2004**.
7. D.P. Kothari & J.S. Dhillon, ‘Power System Optimization’, Prentice-Hall of India, **2010**.

Course Outcomes: Students will be able to:
1. Knowledge about vector spaces, linear transformation, Eigen values and Eigen vectors of

linear operators.
2. To learn about linear programming problems and understanding the simple method for solving linear programming problems in various fields of science and technology.
3. Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems.
4. Understanding the concept of random variables, functions of random variable and their probability distribution.
5. Understand stochastic processes and their classification.

PULSE WIDTH MODULATION FOR POWER ELECTRONICS CONVERTERS

Subject Code: MELEE1-162 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

Course Objectives: Students will be able to:
1. To understand Necessity and Importance of PWM techniques.
2. Implementation of PWM controllers.

UNIT-I (8 Hrs.)

Introduction to Power Electronics Converters:
Modulation of One Inverter Phase Leg: Fundamental concepts of PWM, Evaluation of PWM schemes, Naturally sampled PWM, PWM analysis by duty cycle variation, Regular sampled PWM, Direct modulation.
Modulation of Single-phase Voltage Source Inverter: Topology of a single phase inverter, Three level modulation of a single phase inverter, Harmonic losses.
Modulation of Three-phase Voltage Source Inverter: Topology of three phase inverter (VSI), Three phase modulation with sinusoidal references, harmonic losses, discontinues modulation.

UNIT-II (8 Hrs.)

Zero Space Vector Placement Modulation Strategies: Space vector modulation, Harmonic losses for SVM, Placement of the Zero space vector, Discontinuous modulation (120,60,30 degree), Harmonic losses for discontinuous PWM.
Modulation of Current Source Inverter: Three phase modulators as state machines, Naturally sampled CSI space vector modulator.

UNIT-III (8 Hrs.)

Over modulation of an Inverter: The over modulation region, naturally sampled and regularly sampled over modulation of one phase leg of an inverter, naturally sampled over modulation of single-phase and three-phase inverters.
Programmed Modulation Strategies: optimized space vector modulation, harmonic elimination PWM, Performance Index for optimality, Optimum PWM, Minimum loss PWM.

UNIT-IV (6 Hrs.)

Pulse Width Modulation for Multilevel Inverters: PWM of cascaded single phase H-bridges, Over modulation of cascaded H bridges, PWM alternatives for diode-clamped multilevel inverters, three level naturally sampled PD PWM, Over modulation of three level inverters, five level PWM for diode clamped inverters. PWM of higher level inverters.

UNIT-V (4 Hrs.)

Implementation of Modulation Controller: Overview of a power electronic conversion system, Elements of a PWM converter system, Hardware implementation of the PWM process, PWM software implementation.

UNIT-VI (6 Hrs.)

Continuing Developments in Modulation: Random PWM, PWM Rectifier with Voltage unbalance, Effect of minimum pulse width, PWM Dead-Time compensation.

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.

Recommended Books:

1. D. Grahame Holmes, Thomas A. Lipo, 'Pulse width modulation of Power Converter: Principles and Practice', John Wiley & Sons, **2003.**
2. Bin Vew, 'High Power Converter', Wiley Publication.
3. Marian K. Kazimicrczuk, 'Pulse Width modulated dc-dc Power Converter', Wiley Publication.

Course Outcomes: Students will be able to:

1. Appreciate importance of PWM techniques.
2. Implement PWM using different strategies.
3. Control CSI and VSI using PWM.
4. Compare performance of converter for different PWM techniques.

ELECTRIC AND HYBRID VECHILES

Subject Code: MELEE1-163 **L T P C** **Duration: 40 Hrs.**
3 0 0 3

UNIT-I (7 Hrs.)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, Mathematical models to describe vehicle performance.

UNIT-II (7 Hrs.)

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.

Electric Drive-Trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT-III (7 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.

UNIT-IV (6 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.

UNIT-V (6 Hrs.)

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-VI (7 Hrs.)

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. Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding Mode Control of Switching Power Converters'.

Course Outcomes: Students will be able to:

1. Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. To learn electric drive in vehicles/traction.