Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Master of Technology in Electrical & Electronics Engineering (Power Systems)

Department of Electrical & Electronics Engineering
Silicon Institute of Technology
Silicon Hills, Patia, Bhubaneswar - 751024

Effective from Academic Year 2018-19
Version: 1.20 (Build: 25-09-2020)

Approval History

ACM#	Date	Resolutions
AC-1	14/08/2018	The curriculum & detailed syllabus of 1st Year, as proposed by the Board of Studies, is provisionally approved by the Academic Council.
AC-2	11/05/2019	The curriculum & detailed syllabus up to 2nd Year, as proposed by the Board of Studies, is approved by the Academic Council.

Program Outcomes

Program Outcomes (POs) form a set of individually assessable outcomes that are the components indicative of the post-graduate's potential to acquire competence to practice at the appropriate level. The following POs have been defined for the M.Tech programmes in line with NBA, so that the outcomes can be assessed in a similar manner to UG Engineering programmes:

PO1. Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.

PO2. Design the modern electric machines, drives, power converters, and control circuits for specific applications.

PO3. Use modern tools, professional software platforms, embedded systems for the diversified applications.

PO4. Solve the problems which need critical and independent thinking to show reflective learning.

PO5. Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.

PO6. Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

PO7. Understand the impact of power electronics devices in an economic, social and environment context.

PO8. Understand intellectual property rights and overall professional & ethical responsibility.

PO9. Communicate effectively in a technically sound manner with a wide range of audience.

PO10. Continue to learn independently and engage in life-long learning.

Program Educational Objectives (PEOs)

PEO1. **Fundamental Knowledge**: To provide students with a foundation in mathematics, physics and core electrical and electronic areas required to formulate, solve and analyze engineering problems.

PEO2. **Professional Skill & Society**: To analyze real life problems; apply the knowledge gained from modern design methodologies to address issues in a manner i.e., technically sound, economically feasible and socially acceptable.

PEO3. **Ethics & Lifelong Learning**: To inculcate ethical attitude, effective communication skills, teamwork in their profession and adapt to current trends by engaging in lifelong learning needed for a successful professional career.

Program Specific Outcomes (PSOs)

PSO1. **Engineering Knowledge and Analysis**: Apply engineering fundamental knowledge to identify, formulate, design and investigate complex engineering problems of electric circuits, power electronics, electrical machines and power systems and to succeed in competitive exams.

PSO2. **System Design & Professionalism**: Apply appropriate techniques and modern engineering hardware and software tools in power systems and power electronics to meet desired needs within realistic constraints such as economical, environmental, social, political, ethical, health and safety, manufacturability and sustainability.

PSO3. **Leadership & Lifelong Learning**: Function effectively as an individual or a leader in a team to manage different projects in multidisciplinary environment and appreciate the need for, and an ability to engage in life-long learning.

Course Types & Definitions

L	Lecture
T	Tutorial
P	Practical / Sessional
WCH	Weekly Contact Hours
BS	Basic Sciences
HS	Humanities & Social Sciences (including Management)
ES	Engineering Sciences
PC	Professional Core
PE	Professional Elective
OE	Open Elective
MC	Mandatory Course
CC	Compulsory Course
AC	Audit Course
PJ	Project Work
VV	Viva Voce

Contents

Part I

1st Year M.Tech. (EEE)
(Power Systems)

Curriculum Structure

Semester I									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18MP1T01	Computational Methods for Power System Engineering	3	0	0	3	0	0
PC	18MP1T02	Power System Analysis	3	0	0	3	0	0
PC	18MP1T03	Power System Dynamics	3	0	0	3	0	0
PE	18MP2T**	Professional Elective-I	3	0	0	3	0	0
CC	18MS1T05	Research Methodology & IPR	2	0	0	2	0	0
AC	18MS8T06	Stress Management by Yoga	2	0	0	0	0	0
PRACTICAL									
PC	18MP1L01	Power Systems Lab-I	0	0	4	0	0	2
PC	18MP1L02	Renewable Energy Lab	0	0	4	0	0	2
		SUB-TOTAL	**16**	**0**	**8**	**14**	**0**	**4**
		TOTAL	**24**			**18**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - I
18MP2T03	Renewable Energy Systems
18MP2T04	Smart Grids
18MP2T01	High Power Converters
18MP2T02	Wind & Solar Systems

Semester II									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18MP1T07	Digital Protection of Power System	3	0	0	3	0	0
PE	18MP2T**	Professional Elective-II	3	0	0	3	0	0
PE	18MP2T**	Professional Elective-III	3	0	0	3	0	0
PE	18MP2T**	Professional Elective-IV	3	0	0	3	0	0
AC	18MS8T11	English for Research Paper Writing	2	0	0	0	0	0
PRACTICAL								
PC	18MP1L03	Power Systems Lab-II	0	0	4	0	0	2
PC	18MP1L04	Power Electronics Applications to Power Systems Lab	0	0	4	0	0	2
PJ	18MP6L05	Mini Project & Seminar	0	0	4	0	0	2
		SUB-TOTAL	**18**	**0**	**10**	**18**	**0**	**4**
		TOTAL	**28**			**22**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - II
18MP2T05	Electrical Power Distribution Systems
18MP2T08	PWM for PE Converters
18MP2T06	Electric and Hybrid Vehicles
	Professional Elective - III
18MP2T09	Restructured Power Systems
18MP2T07	Advanced Digital Signal Processing
18MP2T12	Power System Planning & Reliability
18MP2T11	Power Apparatus Systems
	Professional Elective - IV
18MP2T13	Advanced Micro-Controller Based Systems
18MP2T14	SCADA System and Applications
18MP2T10	Power Quality
18MP2T15	AI Techniques

Type	Code	Computational Methods for Power System Engineering	L-T-P	Credits	Marks
PC	18MP1T01		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to basic concepts of mathematics, optimization and soft computing methods. The course will cover different optimization techniques for linear and nonlinear programming. The course will train the students about the basic tools of soft computing like fuzzy logic and neural networks and their application to different electrical and power systems problems.
Pre-Requisites	Knowledge of engineering mathematics and Power systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Linear Programming: Graphical Method, Simplex Method, Methods of Artificial Variables, Alternate optima, redundancy & degeneracy, Integer Linear Programming: Gomory's cutting Plane Method for All Integer & Mixed Integer Programming, Branch & Bound Method.	**9 Hours**
Module-2	Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/sufficient optimality conditions, duality in non-linear programming. Unconstrained optimization- Line search methods for uni-modal functions, the steepest descent method, Newton's method, Modified Newton's Method, The Conjugate Gradient Method.	**9 Hours**
Module-3	Constrained Optimization: Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty function method, Barrier Function Method, Karmakar's Algorithm for Linear Programming, centering transformation, projection matrix and the complete Algorithm.	**7 Hours**
Module-4	Fuzzy logic: Basic concepts of Fuzzy logic, Fuzzy Vs crisp set, Linguistic variables, membership functions, operation of fuzzy sets, fuzzy if then rules, Variable inference techniques, De fuzzification, basic fuzzy inference algorithm, fuzzy system design, FKBC and PID control, control of electrical drive using fuzzy controller and other industrial application.	**10 Hours**
Module-5	Neural networks: Artificial neural network and introduction, learning rules, knowledge representation and acquisition, different methods of learning, Algorithm of neural network: feed forward back propagation, Hopfield model, Kohonen's feature map, K-means clustering, ART networks, RBFN, application of neural network to electrical problems.	**10 Hours**
	Total	**45 Hours**

Text Books:

T1. S. Chandra, Jayadeva, and A. Mehera, ***Numerical Optimization with Applications***, 1st Edition, Narosa Publishing, 2013.

T2. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro-Fuzzy and Soft-Computing***, Prentice-Hall India, 2008.

Reference Books:

R1. S. S. Rao, ***Engineering Optimization***, 3rd Edition, New Age Publishers, 2013.
R2. K. Dev, ***Optimization for Engineering Design***, 2nd Edition, Prentice-Hall India, 2004.
R3. S. Haykins, ***Neural Networks: A Comprehensive Foundation***, 3rd Edition, Pearson Education India, 2011.
R4. V. Kecman, ***Learning and Soft Computing: Support Vector Machines, Neural Networks, and Fuzzy Logic Models***, Pearson Education India, 2006.

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

CO1	Apply linear programming methods to engineering problems.
CO2	Understand and apply methods of solutions for unconstrained optimization problems.
CO3	Understand and apply methods of solutions for constrained optimization problems.
CO4	Study and design fuzzy logic controllers for different electrical applications.
CO5	Learn different neural networks and its application to solve different electrical problems.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1	2	2						3	1	
CO2	3	3	2	3	2						3	2	1
CO3	3	3	2	3	2						3	2	1
CO4	3	3	3	2	2					1	3	3	1
CO5	3	3	3	2	2					1	3	3	2

Type	Code	Power System Analysis	L-T-P	Credits	Marks
PC	18MP1T02		3-0-0	3	100

Objectives	The objective of this course is to enable students to study various methods of load flow and their implications, understand how to analyze various types of faults in power systems, understand power system security concepts and study the methods to rank the contingencies, articulate the need of state estimation and study simple algorithms for state estimation, and study voltage instability phenomenon in power systems.
Pre-Requisites	Knowledge of Mathematics such as calculus, ordinary differential equations, matrices, solving circuit problem using nodal and mesh current method, and synchronous machines are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Load flow**: Overview of Newton-Raphson, Gauss-Seidel, Fast decoupled methods, convergence properties, Sparsity techniques, Handling Qmax violations in constant matrix, Inclusion in frequency effects, AVR in load flow, Handling of discrete variable in load flow.	**10 Hours**
Module-2	**Fault Analysis**: Simultaneous faults, Open conductors' faults, Generalized method of fault analysis.	**8 Hours**
Module-3	**Security Analysis**: Security state diagram, Contingency analysis, Generator shift distribution factors, Line outage distribution factor, Multiple line outages, Overload index ranking.	**8 Hours**
Module-4	**Power System Equivalents**: WARD, REI, equivalents; State Estimation: Sources of errors in measurement, Virtual and Pseudo, Measurement, Observability, Tracking state estimation, WSL method, Bad data correction.	**8 Hours**
Module-5	**Voltage Stability**: Voltage collapse, P-V curve, Multiple power flow solution, Continuation of power flow, Optimal multiplies load flow, Voltage collapse proximity indices.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Grainger & W. D. Stevenson, ***Power System Analysis***, 1st Edition, McGraw-Hill, 2017.
T2. A. R. Bergen & V. Vittal, ***Power System Analysis***, 2nd Edition, Pearson, 2002.
T3. A. J. Wood, ***Power Generation, Operation and Control***, 3rd Edition, John Wiley, 2013.

Reference Books:

R1. L. P. Singh, ***Advanced Power System Analysis and Dynamics***, 6th Edition, New Age International, 2012.
R2. G. L. Kusic, ***Computer Aided Power System Analysis***, 2nd Edition, Prentice Hall India, 2008.

R3. P. M. Anderson, ***Faulted Power System Analysis***, IEEE Press, 1995.

Online Resources:

1. http://nptel.ac.in/courses/108102047/26
2. https://courses.engr.illinois.edu/ece476/fa2016/Lecture%20Notes/
3. https://onlinecourses.nptel.ac.in/noc18_ee16/preview

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

CO1	Apply various methods of load flow to calculate voltage phasor at all buses with given data.
CO2	Ability to calculate fault currents in each phase for symmetrical and unsymmetrical faults in power systems.
CO3	Rank various contingencies according to their severity in terms of bus voltage and line loading.
CO4	Estimate the bus voltage phasor given various quantities such as power flow, voltages, taps, CB status etc.
CO5	Estimate closeness to voltage collapse and calculate PV curves using continuation power flow.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	1	2							3	3	1
CO2	3	3	2	2							3	2	1
CO3	3	2	1	1			1	1			3	2	
CO4	3	2	2	1			1	1			3	2	
CO5	3	3	2	1							3	2	

Type	Code	Power System Dynamics	L-T-P	Credits	Marks
PC	18MP1T03		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to basic concepts of power system dynamics. This course will introduce the dynamic behavior of the system and its effect on the stability of the power system. The course will cover different types of stability analysis and methods for improving the stability.
Pre-Requisites	Knowledge of power systems and operating characteristics of different power system components.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic Concepts of Dynamic Systems and Stability Definition, Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System.	**8 Hours**
Module-2	Effect of Damper, Flux Linkage Variation and AVR, Dynamic Analysis of Voltage Stability Voltage Collapse.	**10 Hours**
Module-3	Large Signal Rotor Angle Stability, Dynamic Equivalents and Coherency, Direct Method of Stability Assessment, Stability Enhancing Techniques, Mitigation Using Power System Stabilizer.	**10 Hours**
Module-4	Asynchronous Operation and Resynchronization, Multi-Machine Stability.	**8 Hours**
Module-5	Frequency Stability, Automatic Generation Control, Primary and Secondary Control Sub-Synchronous Resonance and Counter Measures.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. P. Kundur, ***Power System Stability and Control***, 1st Edition, McGraw-Hill, 2006.
T2. J. Machowski, J. Bialek, J. Bumby, ***Power System Dynamics and Stability***, 2nd Edition, John Wiley & Sons, 2008.

Reference Books:

R1. L. Leonard Grigsby (Ed.), ***Power System Stability and Control***, 2nd Edition, CRC Press, 2007.
R2. V. Ajjarapu, ***Computational Techniques for Voltage Stability Assessment & Control***, Springer, 2006.

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

CO1	Ability to analyze the small signal stability of the power system.
CO2	Understand the effect of excitation system and voltage stability of the power system.
CO3	Ability to analyze the rotor angle stability and design techniques to improve the stability of the system.

Cont'd...

CO4	Gain knowledge of multi-machine stability and asynchronous operation.
CO5	Understand modeling of automatic generation control of single/multi-area systems and sub-synchronous resonance in power systems.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	1	2							2	1	
CO2	3	3	2	2							3	2	
CO3	3	2	1	1			1	1			3	1	
CO4	3	2	2	1			1	1			3	2	1
CO5	3	3	2	1							3	2	

Type	Code	Renewable Energy Systems	L-T-P	Credits	Marks
PE	18MP2T03		3-0-0	3	100

Objectives	The objective of the course is to expose the students to real time working principles of distributed generation systems with renewable energy sources, its sizing, economics, dynamics of off-grid and grid-connected schemes.
Pre-Requisites	Knowledge of UG level mathematics, physics, control system, electrical machines, and power electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Need for Distributed Generation (DG), Renewable sources in distributed generation and current scenario in distributed generation.	**6 Hours**
Module-2	Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine-based interfaces, Aggregation of multiple DG units.	**8 Hours**
Module-3	Technical impacts of DGs, Transmission & Distribution Systems, De-regulation Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis.	**8 Hours**
Module-4	Economic and control aspects of DGs Market facts, Issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems.	**8 Hours**
Module-5	Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids, Sizing of micro-grids, Modelling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units.	**8 Hours**
Module-6	Transients in micro-grids, Protection of micro-grids, Case studies and advanced topics.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. H. L. Willis & W. G. Scott, ***Distributed Power Generation – Planning and Evaluation***, 2nd Edition, CRC Press, 2004.
T2. E. Amir, ***Microgrids: Operation, Control, and Protection***, Lambert Academic Publishing, 2014.
T3. M. G. Simões & F. A. Farret, ***Renewable Energy Systems – Design and Analysis with Induction Generators***, CRC Press, 2004.

Reference Books:

R1. S. Borlase, ***Smart Grid: Infrastructure Technology Solutions***, 1st Edition, CRC Press, 2017.

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

CO1	Understand various renewable sources in Distributed Generation (DG).
CO2	Understand sitting, sizing, optimal placement & grid integration of DG sources in distribution and transmission systems.
CO3	Analyze the steady state and dynamic performance in control of DG systems.
CO4	Evaluate the economics and reliability aspects of DGs.
CO5	Study types of microgrids and apply modeling techniques to microgrids with multiple DGs.
CO6	Study dynamics and protection of microgrids.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2			2				1		1
CO2	3	3	2	2			1				2	2	2
CO3	3	3	2	3			2				3	2	2
CO4	3	3	1	1			1				3	1	2
CO5	3	3	3	3							2	2	2
CO6	3	3	3	3							3	1	2

Type	Code	Smart Grids	L-T-P	Credits	Marks
PE	18MP2T04		3-0-0	3	100

Objectives	The objective of the course is to learn the concepts of smart grid, its advantages, smart metering technique, wide area measurement technique, and develop understanding of the solutions of problems associated with integration of distributed generation through smart grid.
Pre-Requisites	Knowledge of conventional grid, renewable energy systems, and power electronics converters are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Smart Grid**: Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid. Concept of Robust & Self-Healing Grid, Present development & International policies in Smart Grid.	**6 Hours**
Module-2	**Smart Meters and Sensors**: Introduction to Smart Meters, Real Time Prizing, 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, Advanced Metering Infrastructure (AMI), Home Area Network (HAN) (HAN). Neighborhood Area Network (NAN), Wide Area Network (WAN).	**10 Hours**
Module-3	**Advanced Techniques in Smart Grid**: Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro. Compressed Air Energy Storage. Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). Bluetooth, ZigBee, 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.	**12 Hours**
Module-4	**Micro Grid**: Concept of micro-grid, need & applications of micro-grid, Formation of micro-grid, Issues of interconnection, Protection & control 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.	**8 Hours**
Module-5	**Power Quality**: Power Quality & EMC in 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.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. A. Keyhani, ***Design of Smart Power Grid Renewable Energy Systems***, Wiley-IEEE Press, 2016.
T2. C. W. Gellings, ***The Smart Grid: Enabling Energy Efficiency and Demand Response***, CRC Press, 2009.
T3. A. G. Phadke, ***Synchronized Phasor Measurement and their Applications***, 2nd Edition, Springer, 2008.

Reference Books:

R1. J. B. Ekanayake, N. Jenkins, K. Liyanage, and others, ***Smart Grid: Technology and Applications***, 1st Edition, Wiley, 2012.
R2. S. Borlase, ***Smart Grid: Infrastructure, Technology and Solutions***, 1st Edition, CRC Press, 2017.

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

CO1	Appreciate the difference between smart grid & conventional grid.
CO2	Apply smart metering concepts to industrial and commercial installations.
CO3	Formulate solutions in the areas of smart substations, distributed generation and wide area measurements.
CO4	Design & develop smart grid solutions using modern communication technologies.
CO5	Study the power quality problems associated with integration of renewable energy sources in smart grid.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	2							2		1
CO2	2	3	2	1							2	2	2
CO3	3	2	1	2			1	1			3	2	2
CO4	2	2	2	1			1	1			2	2	2
CO5	2	2	1	2			1				2	2	2

Type	Code	High Power Converters	L-T-P	Credits	Marks
PE	18MP2T01		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to different type of Power Electronics converters. The students will know about various design aspects as well as protection schemes of the converters.
Pre-Requisites	Knowledge of basic electronics and semiconductor devices is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Power Electronics Systems: Power Electronics versus Linear Electronics, Classification of power processors and converters, Scope and Applications; Overview of Power Semiconductor Devices: Characteristics of controllable switches; Thyristor, GTO, BJT, IGBT, MCT, Comparison of controllable switches; Rectifiers: Multi-pulse Diode rectifiers and multi-pulse SCR rectifiers.	**8 Hours**
Module-2	Multi-level Inverters: Two-level Voltage Source Inverter; Cascaded, H-bridge Multilevel Inverter, Diode Clamped Multilevel Inverters, Flying Capacitor Multilevel Inverter; PWM Current Source Inverter.	**8 Hours**
Module-3	DC-DC Switch mode Converters: Step-up and Step-down converters, Buck-Boost Converters, Cuk Converter, Half bridge and Full bridge Converter, Forward Converter, Flyback Converter, Control of DC-DC Converters.	**8 Hours**
Module-4	AC Voltage Controllers: AC Voltage Controllers with PWM control, Cycloconverters: Mid point type and Bridge type with R and RL load, Matrix Converter.	**8 Hours**
Module-5	Power Conditioners and Uninterruptible Power Supplies: Power line disturbances, Power Conditioners, UPS.	**5 Hours**
Module-6	Practical Converter Design and Protection: Snubber Circuits for Thyristor, Transistors, Overvoltage Snubber, Turn–On and Turn-Off Snubber; Gate and Base Drive Circuits: Design considerations, DC coupled Drive Circuits, Thyristor Drive Circuits, Cascaded Drive Circuits.	**5 Hours**
	Total	**42 Hours**

Text Books:

T1. N. Mohan, T. M. Undeland, and W. P. Robbins, ***Power Electronics: Converter, Applications and Design***, 3rd Edition, John Wiley and Sons, 2003.
T2. M. H. Rashid, ***Power Electronics***, 4th Edition, Pearson Education, 2017.

Reference Books:

R1. B. Wu, M. Narimani, ***High Power Converters and Drives***, 2nd Edition, Wiley-IEEE Press, 2016.

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

CO1	Understand the characteristics of different semiconductor devices and their applications in different converter circuits.
CO2	Learn about different topologies of multi-level inverters and also PWM techniques used in VSI and CSI.
CO3	Learn about different DC-DC switch mode converters and their control techniques.
CO4	Acquire knowledge about different AC voltage controllers and their control.
CO5	Know about the requirement of Power Conditioners and UPS and understand their working.
CO6	Design gate drive circuits and protective circuits for semiconductor devices.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2				1	1				3	2	1
CO2	3	3	2		1	2	1				3	2	
CO3	3	3	3		1	1	1				3	2	
CO4	3	2	2	1	1	1	1				3	2	
CO5	3	3	3	2	2	1	1				3	2	
CO6	3	3	3	3	3	2	2	1		1	3	2	1

Type	Code	Wind & Solar Systems	L-T-P	Credits	Marks
PE	18MP2T02		3-0-0	3	100

Objectives	The objective of the course is to appreciate the importance of energy growth of the power generation from the renewable energy sources and participate in solving these problems, demonstrate the knowledge of the physics of wind power and solar power generation and all associated issues so as to solve practical problems.
Pre-Requisites	Knowledge of UG level mathematics, physics, control system, electrical machines, power electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Historical development, current status, Network integration issues of wind power generation.	**4 Hours**
Module-2	Generators and power electronics for wind turbines, power quality standards for wind turbines, Technical regulations for interconnections of wind farm with power systems.	**8 Hours**
Module-3	Isolated wind systems, reactive power and voltage control, economic aspects.	**8 Hours**
Module-4	Impacts on power systems dynamics, power systems interconnection.	**8 Hours**
Module-5	Introduction of solar systems, merits and demerits, concentrators, Solar thermal power generation, various applications.	**8 Hours**
Module-6	PV power generation, Energy Storage device; Designing the solar systems for small installations.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Ackermann, ***Wind Power in Power Systems***, 2nd Edition, John Willy & Sons, 2005.
T2. S. Heier, ***Grid Integration of Wind Energy Conversion Systems***, 3rd Edition, John Willy & Sons, 2006.
T3. S. P. Sukhatme and J. K. Nayak, ***Solar Energy***, 4th Edition, Tata McGraw-Hill, 2017.

Reference Books:

R1. M. R. Patel, ***Wind and Solar Power Systems: Design, Analysis and Operation***, Taylor Francis, CRC Press, 2005.

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

CO1	Understand the historical development, current status, network integration issues of wind power generation.
CO2	Understand generation, power quality standards & technical regulations for wind energy systems.

Cont'd...

CO3	Understand isolated wind systems, reactive power and voltage control.
CO4	Analyze dynamic performance of interconnected power system with wind energy systems.
CO5	Learn about solar concentrators, Solar thermal power generation, various applications.
CO6	Learn about PV power generation and Energy Storage devices and design the solar systems for small installations.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1	1	1			2				3	1	
CO2	3	2	1	1			2				3	1	1
CO3	3	2	1	2							3	1	1
CO4	3	2	2	2							3	2	1
CO5	3	3	3	2							3	1	1
CO6	3	3	3	3							3	3	2

Type	Code	Research Methodology & IPR	L-T-P	Credits	Marks
CC	18MS1T05		2-0-0	2	100

Objectives	The objective of this course is to introduce students to the principles and practices involved in conducting scientific research. The course is designed to cover three broad areas - The Scientific Method and Hypothesis Testing, Review of Literature and writing Technical Reports, and the elements of Intellectual Property Rights (IPR).
Pre-Requisites	Basic knowledge of probability & statistics will be helpful.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to research, its significance and meaning; Types of research - fundamental, pure, theoretical, applied and experimental; Identification of the research problem and formulation of hypothesis; Research design and errors in research, error analysis; The Scientific Method as the established way of doing research; Data collection, measurement and scaling techniques.	**8 Hours**
Module-2	Meaning and need for hypothesis, types of hypothesis, functions and characteristics of a good hypothesis; Statistical Testing of Hypothesis - T-test, Chi-squared test; Sampling methods, types of sampling, probability and non-probability sampling; One-sample and Two-sample tests. Correlation and Regression analysis.	**8 Hours**
Module-3	Literature - types and review; Literature survey using the web, search engines; Journal, report and thesis writing; Types of reports, structure of the research report and presentation of results.	**8 Hours**
Module-4	Code of ethics in research - Intellectual Property Rights; Details of Patents, Copyrights, Trademarks and Trade Secrets.	**6 Hours**
	Total	**30 Hours**

Text Books:

T1. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2004.
T2. D. Chawla & N.Sodhi, ***Research Methodology: Concepts and Cases***, 2nd Edition, Vikas Publishing, 2016.

Reference Books:

R1. E. L. Lehman & J. P. Romano, ***Testing Statistical Hypothesis***, 3rd Edition, Springer, 2008.
R2. R. Panneerselvam, ***Research Methodology***, 2nd Edition, Prentice Hall India, 2013.

P.T.O

Online Resources:

1. http://nptel.ac.in/courses/107108011: NPTEL Course.
2. https://ocw.mit.edu/courses/sloan-school-of-management/15-347-doctoral-seminar-in-research-methods-i-fall-2004/readings/: MIT Open Courseware (MIT-OCW).

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

CO1	Disseminate the scientific method as a structured way of conducing scientific research.
CO2	Apply statistical principles for conducting hypothesis testing.
CO3	Conduct effective review of literature and write technical reports.
CO4	Acquire knowledge of the various intellectual property rights.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1	1	1					1	1	1	2
CO2	2	2	1	1	1					1		1	1
CO3					3				2	1		1	2
CO4								3		1		1	2

Type	Code	Stress Management by Yoga	L-T-P	Credits	Marks
AC	18MS8T06		2-0-0	0	100

Objectives	To impart skills in students for control of mind, body and soul, enhance self-awareness, improve self-awareness, focus, and concentration, bring together physical and mental wellness, manage stress and anxiety, achieve perfect equilibrium and harmony, and promote self-healing.
Pre-Requisites	There are no pre-requisites for this course.
Teaching Scheme	Regular practice classes conducted under supervision of the qualified Yoga teacher with necessary explanation and demonstration for each session.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Yoga, Pranayama, Mudra, Bandha and Chakra.	**6 Hours**
Module-2	Pawanmuktasana Part 1, various Asanas in standing posture.	**6 Hours**
Module-3	Surya Namaskar set and its benefits.	**6 Hours**
Module-4	Various Asanas in sitting posture.	**6 Hours**
Module-5	Asanas in sleeping posture and various relaxation Asanas.	**6 Hours**
	Total	**30 Hours**

Text Books:

T1. E. F. Bryant, ***The Yoga Sutras of Patanjali***, 1st Edition, North Point Press, 2009.

Reference Books:

R1. Swami Satyananda Saraswati, ***Asana Pranayama Mudra Bandha***, 4th Edition, Yoga Publication Trust, Munger (Bihar), India, 2008.

Online Resources: *There are a number of online resources available for this subject. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

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

CO1	Promote positive health, prevent stress related health problems and rehabilitation through Yoga.
CO2	Achieve integral approach of Yoga Therapy to common ailments.
CO3	Develop skills to adopt Yoga practices for health and general well-being.
CO4	Develop of overall personality through control of body, mind and soul.
CO5	Enhance scientific attitude and team spirit for creative and constructive endeavors.

P.T.O

Program Outcomes Relevant to the Course:

PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1			3	2		2	1
CO2										3		1	1
CO3						2			3	3		2	2
CO4									3	3	1	2	2
CO5						2			2	3	1	2	3

Type	Code	Power Systems Lab-I	L-T-P	Credits	Marks
PC	18MP1L01		0-0-4	2	100

Objectives	The objective of this course is to introduce the students to advanced concepts of power systems. The course will cover the calculation of performance parameters of transmission systems, their improvement strategies. The course will train the students for performance analysis & their improvement to power systems through software & modern tools.
Pre-Requisites	Knowledge of Network Theory, Power Systems Analysis, and Engineering Mathematics are required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Demonstration shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of corona discharge & measurement of breakdown strength of air.
2	Study of Ferranti effect, voltage profile & determination of A, B, C, D parameters.
3	Determination of voltage regulation of a HV transmission line with different loading & study different types of compensators used in HV Transmission line to improve voltage regulation.
4	Determination of Bus admittance & impedance matrices for a given power system network.
5	Load flow study for a given power system using NR & Fast decoupled method.
6	Optimal generator scheduling for thermal power plants.
7	Load-frequency control of a single area power system.
8	Load-frequency control of a two-area power system.
9	Economic load dispatch in power system.
10	Transient and Small Signal Stability Analysis: Single-Machine Infinite Bus System.
11	Transient and Small Signal Stability Analysis: Multi-Machine Power system.

Text Books:

T1. H. Saadat, ***Power System Analysis***, 2nd Edition, Tata McGraw-Hill, 2002.
T2. J. J. Grainger & W. D. Stevenson, ***Power System Analysis***, 1st Edition, McGraw-Hill, 2017.
T3. A. J. Wood, ***Power Generation, Operation and Control***, 3rd Edition, John Wiley, 2013.

Reference Books:

R1. L. P. Singh, ***Advanced Power System Analysis and Dynamics***, 6th Edition, New Age International, 2012.
R2. T. K. Nagsarkar & M. S. Sukhija, ***Power System Analysis***, Oxford University Press, 2007.

P.T.O

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

CO1	Understand and model a power transmission line.
CO2	Measure performance parameters of a power transmission system.
CO3	Develop understanding of understand load flow analysis of a given power system.
CO4	Understand the concepts of load frequency control & economic load dispatch.
CO5	Develop an ability to understand the concepts of generator scheduling.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1									3	1	1
CO2	3	1	3	3	3					1	3	2	1
CO3	3	2	3	2	1					1	3	2	1
CO4	3	1	1								3	1	1
CO5	3	3	3	1	1	1				1	2	1	1

Type	Code	Renewable Energy Lab	L-T-P	Credits	Marks
PC	18MP1L02		0-0-4	2	100

Objectives	The objective of this course in to expose the students to real time working principles of renewable energy systems and distributed generation systems.
Pre-Requisites	Knowledge of UG level mathematics, physics, control system, electrical machines, and power electronics is required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Demonstration shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study single PV module, I-V and P-V characteristics with radiation and temperature changing effect.
2	Study I-V and P-V characteristics with series and parallel combination of modules.
3	Effect of shading and tilt angle on I-V and P-V characteristics of solar module.
4	Find MPP by varying the resistive load by varying the duty cycle of DC-DC converter.
5	Determine the efficiency of Wind Energy System.
6	Study the effect of Load on Solar Panel Output.
7	Determine the output of a bio-gas plant.
8	Determine the efficiency of mini hydro plant.
9	Determine the efficiency of grid tied solar PV system.
10	Build a wind farm.
11	Study power curves of a wind turbine system.
12	Study the effect of load on wind turbine output.
13	Test the capabilities of Hydrogen fuel cell.
14	Study of grid integration of multiple renewable energy sources.
15	Determine the efficiency of a fuel cell.

Text Books:

T1. H. L. Willis & W. G. Scott, ***Distributed Power Generation – Planning and Evaluation***, 2nd Edition, CRC Press, 2004.
T2. E. Amir, ***Microgrids: Operation, Control, and Protection***, Lambert Academic Publishing, 2014.
T3. M. G. Simões & F. A. Farret, ***Renewable Energy Systems – Design and Analysis with Induction Generators***, CRC Press, 2004.

Reference Books:

R1. S. Borlase, ***Smart Grid: Infrastructure Technology Solutions***, 1st Edition, CRC Press, 2017.

P.T.O

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

CO1	Understand operating characteristics and analyze the factors affecting the performance of Solar PV systems.
CO2	Understand operating characteristics and analyze the factors affecting the performance of wind energy systems.
CO3	Understand the operating characteristics of fuel cells.
CO4	Understand the operating characteristics of bio-gas plants.
CO5	Apply modeling techniques to a micro grid with multiple renewable energy systems.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3	2	2		3		1		3	3	1
CO2	3	2	3	2	2		3		1		3	3	1
CO3	3	1	2	2	2		3		1		2	1	2
CO4	3	1	2	2	2		3		1		2	3	1
CO5	3	3	2	2	2		3		1		3	2	2

Type	Code	Digital Protection of Power System	L-T-P	Credits	Marks
PC	18MP1T07		3-0-0	3	100

Objectives	The objective of this course is to study numerical relays, develop mathematical approach towards protection and study algorithms for numerical protection.
Pre-Requisites	Knowledge of power systems operation and protection is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Evolution of digital relays from electromechanical relays, performance and operational characteristics of digital protection.	**4 Hours**
Module-2	Mathematical background to protection algorithms: Finite difference techniques.	**4 Hours**
Module-3	Interpolation formulae: Forward, backward and central difference interpolation Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier analysis, Fourier series and Fourier transform, Walsh function analysis.	**8 Hours**
Module-4	Basic elements of digital protection: Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, the digital relay as a unit consisting of hardware and software.	**8 Hours**
Module-5	Sinusoidal wave-based algorithms: Sample and first derivative (Mann and Morrison) algorithm. Fourier and Walsh based algorithms.	**8 Hours**
Module-6	Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm. Walsh function-based algorithm. Least Squares based algorithms. Differential equation-based algorithms. Traveling Wave based Techniques. Digital Differential Protection of Transformers. Digital Line Differential Protection. Recent Advances in Digital Protection of Power Systems.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. A. G. Phadke & J. S. Thorp, ***Computer Relaying for Power Systems***, 2nd Edition, Wiley/Research Studies Press, 2009.
T2. S. R. Bhide, ***Digital Power System Protection***, PHI Learning, 2014.

Reference Books:

R1. A. T. Johns & S. K. Salman, ***Digital Protection for Power Systems***, New Education Edition, IEEE Press, 1999.
R2. G. Zeigler, ***Numerical Distance Protection***, 4th Edition, Siemens Publicis Corporate Publishing, 2006.

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

CO1	Learn the importance of Digital Relays for power system protection.
CO2	Apply mathematical approach to develop protection algorithms.
CO3	Obtain mathematical background on various interpolation formulas.
CO4	Learn the basic requirements of digital protection.
CO5	Develop sinusoidal wave based algorithms for protection of power system.
CO6	Develop various Fourier algorithms and their application in digital protection of power systems.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1									2		
CO2	2	1	3	3	3					1	2	2	1
CO3	2	2	3	2	1					1	2	2	1
CO4	2	1	1								2	1	
CO5	2	1	3	1	1	1				1	2	2	1
CO6	2	1	3	1	1	1				1	2	2	1

Type	Code	Electrical Power Distribution Systems	L-T-P	Credits	Marks
PE	18MP2T05		3-0-0	3	100

Objectives	The objective of this course is to familiarize students with rudimentary concepts and design of modern power distribution system, technologies adopted for its automation, maintenance and protection.
Pre-Requisites	Concepts of power flow, power system operation & control are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Distribution of power, management, power loads, Short term and long term load forecasting, Methods of load forecasting, Power system loading, Technological forecasting.	**8 Hours**
Module-2	Advantages of distribution management system (DMS), Distribution automation, Restoration/ Reconfiguration of distribution network, Different methods and constraints, Power factor correction.	**8 Hours**
Module-3	Interconnection of distribution, Control and communication systems, Remote metering, Automatic meter reading and its implementation.	**8 Hours**
Module-4	SCADA: Introduction and block diagram, Application of SCADA in distribution automation, Common functions of SCADA, Advantages of distribution automation through SCADA.	**8 Hours**
Module-5	Calculation of optimum number of switches, capacitors, Optimum switching device placement in radial distribution systems, Sectionalizing switches: Types and benefits, Bellman's optimality principle, Remote terminal units, Energy efficiency in electrical distribution and monitoring.	**6 Hours**
Module-6	Maintenance of automated distribution system, Difficulties in implementing distribution, Automation in actual practice, Urban/rural distribution, Energy management, Artificial Intelligence techniques applied to distribution automation.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. A.S. Pabla, ***Electric Power Distribution***, 6th Edition, Tata McGraw-Hill, 2017.
T2. J. Momoh, ***Electric Power Distribution, Automation, Protection & Control***, CRC Press, 2008.

Reference Books:

R1. M. K. Khedkar, G. M. Dhole, ***A Text Book of Electrical Power Distribution Automation***, 1st Edition, University Science Press, New Delhi, 2010.
R2. A. J. Panseni, ***Electrical Distribution Engineering***, 6th Edition, CRC Press, 2000.

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

CO1	Understand intricacies of distribution of electrical power and methods of load forecasting.
CO2	Acquire knowlege of distribution management system, interconnected power system and power system automation.
CO3	Learn SCADA and its application in real-world power distribution problems.
CO4	Understand various applications of artificial intelligence techniques in distribution automation.
CO5	Determine the optimal placement of switching devices in distribution network to minimize losses and improve the performance.
CO6	Gain knowledge on different aspects of distribution system maintenance and energy management.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2		2	3					2	2	
CO2	3	3			2	3					3	1	
CO3	2	2	2		3	2					1	2	1
CO4	2	2	2		3	3					2	2	1
CO5	3	2	2		2	2					3	2	
CO6	2	3	3		2	2					2	2	

Type	Code	PWM for PE Converters	L-T-P	Credits	Marks
PE	18MP2T08		3-0-0	3	100

Objectives	The objective of this course is to introduce the necessary knowledge to understand the Pulse Width Modulation (PWM) techniques and implementation of various PWM controllers.
Pre-Requisites	Concepts of converter topology, PE converters and its analysis of PWM switching schemes and some knowledge of MATLAB are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to power electronics converters, Modulation scheme of one inverter phase leg, Modulation strategy of single phase converter, voltage source inverter and its analysis.	**8 Hours**
Module-2	Modulation strategies based on zero space vector placement, Losses-discontinuous modulation technique, Modulation technique for CSI.	**8 Hours**
Module-3	Analysis of converters with over modulation technique, programme modulation strategies applied to converters.	**8 Hours**
Module-4	Different modulation schemes for multilevel inverters, Implementation of modulation controller.	**8 Hours**
Module-5	Developments in modulation as random PWM, Application of PWM for voltage unbalance system.	**6 Hours**
Module-6	Minimum pulse width and its effect, necessity of providing dead time.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. D. G. Holmes and T. A. Lipo, ***Pulse Width Modulation of Power Converter: Principles and Practices***, John Wiley & Sons, 2014.
T2. N. Mohan, T. M. Undeland, and W. P. Robbins, ***Power Electronics: Converters, Applications, and Design***, 3rd Edition, John Wiley & Sons, 2002.
T3. B. Vew, ***High Power Converter***, 2nd Edition, Wiley Publication, 2016.

Reference Books:

R1. M. K. Kazimicrczuk, ***Pulse Width Modulated DC-DC Power Converter***, Wiley Publication, 2008.
R2. L. D. Branko and B. Branko, ***Power Electronics: Converters and Regulators***, Springer Publication.

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

CO1	Aquire a deep insight in to the power electronics converters and its modulation techniques.
CO2	Learn advanced modulation strategies such as zero space vector placement, loss discontinuous and modulation applied to current source inverter.

Cont'd...

CO3	Analyze the concept of over modulation and programmed modulation techniques applied to converters.
CO4	Understand advanced switching (modulation) techniques implemented in multilevel inverter and its control strategies.
CO5	Study development in modulation scheme and its application for unbalanced voltage system.
CO6	Realize the necessity of providing minimum pulse width and its effect.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2					3	2	
CO2	3	2	2	1	2	1					3	2	
CO3	3	2	1	1	1	2					3	1	
CO4	2	2	3	1	2	2					3	3	1
CO5	2	2	2	1	2	2					2	2	
CO6	2	1	2	1	1	1					2	1	

Type	Code	Electric and Hybrid Vehicles	L-T-P	Credits	Marks
PE	18MP2T06		3-0-0	3	100

Objectives	The objective of the course is to learn upcoming technology of hybrid systems, different aspects of drive applications and electric traction.
Pre-Requisites	Knowledge on drives and power system operations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance.	**9 Hours**
Module-2	Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.	**9 Hours**
Module-3	Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, drive system efficiency.	**9 Hours**
Module-4	Matching the electric machine and the Internal Combustion Engine (ICE), Sizing the propulsion motor, Sizing the power electronics, Selecting the energy storage technology, Communications, supporting subsystems.	**8 Hours**
Module-5	Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies, Implementation issues of energy strategies.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. S. C. Tan, Y. M. Lai, and C. K. Tse, ***Sliding Mode Control of Switching Power Converters***, 1st Edition, CRC Press, 2017.

T2. S. Ramirez and R. S. Ortigoza, ***Control Design Techniques in Power Electronics Devices***, Springer.

Reference Books:

R1. M. Nikowitz (Ed.), ***Advanced Hybrid and Electric Vehicles: System Optimization and Vehicle Integration***, Springer.

Online Resources:

1. https://nptel.ac.in/downloads/108103009/
2. https://www1.eere.energy.gov/hydrogenandfuelcells/tech_validation/.../fcm08r0.pdf

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

CO1	Learn the basic concepts, mathematical models and social/environmental importance of hybrid and electric vehicles.
CO2	Understand fundamental concepts of hybrid tractions, hybrid drive-train topologies and hybrid drive-train topologies.
CO3	Understand and learn about different drive applications in hybrid vehicles.
CO4	Understand concepts of selection and sizing of components and communication subsystems.
CO5	Acquire insight into energy management in hybrid and electric vehicles.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	1	2				2	1	
CO2	2	2	1	1	2	1					2	1	
CO3	3	1			1	1					3		
CO4	1	2	1		2	1	1				2	2	
CO5	1	1	1		2	3	2				2	1	

Type	Code	Restructured Power Systems	L-T-P	Credits	Marks
PE	18MP2T09		3-0-0	3	100

Objectives	The objective of this course is to make the students understand meaning of restructuring of the electricity market, help them understand the need behind requirement for deregulation of the electricity market, and train them about the basic money, power & information flow in a deregulated power system.
Pre-Requisites	Knowledge of power systems and economics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization.	**8 Hours**
Module-2	OPF: Role in vertically integrated systems and in restructured markets, congestion management.	**8 Hours**
Module-3	Optimal bidding, Risk assessment, Hedging, Transmission pricing, Tracing of power.	**8 Hours**
Module-4	Ancillary services, Standard market design, Distributed generation in restructured markets.	**8 Hours**
Module-5	Developments in India, IT applications in restructured markets.	**6 Hours**
Module-6	Working of restructured power systems, PJM, Recent trends in Restructuring.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. L. Philipson and H. L. Willis, ***Understanding Electric Utilities and De-regulation***, 2nd Edition, Marcel Dekker Pub., 2005.
T2. S. Stoft, ***Power System Economics: Designing Markets for Electricity***, Wiley-IEEE Press, 2002.

Reference Books:

R1. K. Bhattacharya, J. E. Daadler, and M. H. J. Boolen, ***Operation of Restructured Power Systems***, 1st Edition, Kluwer Academic Pub.,2001.
R2. Md. Shahidehpour and M. Alomoush, ***Restructured Electrical Power Systems: Operation, Trading and Volatility***, 1st Edition, Marcel Dekker Pub., 2001.

Online Resources:

1. http://nptel.ac.in/courses/108101005/
2. http://nptel.ac.in/courses/108101005/2
3. https://ieeexplore.ieee.org/stamp/sta/mp.jsp?arnumber=993762
4. https://www.slideshare.net/sarapluto999/restructuring-of-power-grid

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

CO1	Describe the Technical and Non-technical issues in Deregulated Power Industry.
CO2	Understand OPF technique in regulated and restructured systems and its application to congestion management.
CO3	Classify different pricing mechanisms in deregulated environment.
CO4	Identify the importance of ancillary services in restructured power systems.
CO5	Develop IT infrastructure for restructured power systems with emphasis to development in India.
CO6	Discuss the recent trends in restructuring of power systems and their operation.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1			1		2	2						1	
CO2	2		2	1		2						1	
CO3	3		3	1			1				2	2	
CO4			1	1	2	2	1				1	1	
CO5			3			1	3				1	2	1
CO6			1	1			1				1		1

Type	Code	Advanced Digital Signal Processing	L-T-P	Credits	Marks
PE	18MP2T07		3-0-0	3	100

Objectives	The objectives of this course is to make the students comprehend mathematical modeling of discrete time random signals, choose appropriate filter structures, estimation, prediction and filtering concepts and techniques, and develop understanding of the DSP based real-time data processing system for various DSP based high speed applications.
Pre-Requisites	Knowledge of Signals & Systems and Digital Signal Processing is required.
Teaching Scheme	Regular classroom lectures with use of signal processing tools as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and pre-requisites.	**2 Hours**
Module-1	Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design & structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, parallel realization of IIR.	**10 Hours**
Module-2	Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding.	**5 Hours**
Module-3	Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.	**8 Hours**
Module-4	Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm.	**6 Hours**
Module-5	Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.	**8 Hours**
Module-6	Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications.	**5 Hours**
	Total	**44 Hours**

Text Books:

T1. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithm and Applications***, 4th Edition, Prentice Hall, 2007.

Reference Books:

R1. N. J. Fliege, ***Multirate Digital Signal Processing: Multirate Systems -Filter Banks- Wavelets***, 1st Edition, John Wiley and Sons, 1999.
R2. B. W. Suter, ***Multirate and Wavelet Signal Processing***, 1st Edition, Academic Press, 1997.
R3. M. H. Hayes, ***Statistical Digital Signal Processing and Modeling***, John Wiley & Sons, 2002.
R4. 5. S.Haykin, ***Adaptive Filter Theory***, 4th Edition, Prentice Hall, 2001.
R5. D. G. Manolakis, V.K. Ingle, and S. M. Kogon, ***Statistical and Adaptive Signal Processing***, McGraw Hill, 2000.

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

CO1	Analyze and design FIR and IIR digital filters using various filtering methods.
CO2	Understand multirate signal processing and compare sampling rate conversion methods using different sampling rate converters.
CO3	Get an insight of linear filters and perform critical evaluation of linear predictors using different methods.
CO4	Understand the principles of adaptive filtering and design the filters using LMS and RLS algorithms.
CO5	Estimate the power spectrum of corrupted signals through different estimation techniques.
CO6	Apply signal processing techniques in different areas such as image processing, wireless communication, biomedical engineering, speech processing, video processing, etc.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3		1	2	1	1	2			2	3	2	1
CO2	3		1	2	2	1	2			3	3	1	2
CO3	2		2	3	2	1	1			2	2	1	2
CO4	2		1	2	2	2	3			3	2	2	1
CO5	3		2	3	2	2	2			2	2	2	1
CO6	3		3	3	3	3	3			3	3	2	3

Type	Code	Power System Planning & Reliability	L-T-P	Credits	Marks
PE	18MP2T12		3-0-0	3	100

Objectives	The objective of this course is to learn load forecasting, power system planning & power reliability issues in power systems, to arm the students with the concepts of evaluation of generation, transmission & distribution system reliability and their impacts on system planning.
Pre-Requisites	Knowledge of Power System Analysis, Electric Power Generation, Transmission and Distribution is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Load forecasting: Objectives of forecasting - Characteristics of loads – methodology of forecasting, Load growth patterns and their importance in planning - Load Forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting- Energy forecasting – Peak demand forecasting – Total forecasting – Annual and monthly peak demand forecasting, Use of AI in load forecasting.	**10 Hours**
Module-2	Generation system reliability analysis: Reliability concepts – Exponential distributions – Meantime to failure – Series and parallel system – MARKOV process – Recursive technique, Probabilistic generation and load models-Determination of LOLP and expected value of demand not served – Determination of reliability of isolated and interconnected generation systems.	**10 Hours**
Module-3	Transmission system reliabilityanalysis: Deterministic contingency analysis - probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not serve.	**8 Hours**
Module-4	Expansion planning: Objectives of planning – Long and short term planning - procedure followed for integrate transmission system planning, current practice in India - Capacitor placer problem in transmission system and radial distributions system.	**8 Hours**
Module-5	Distribution system planning: Introduction, sub transmission lines and distribution substations - Design primary and secondary systems - distribution system protection and coordination of protective devices.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. R. Billinton and R. N. Allan, ***Reliability Evaluation of Power Systems***, 2nd Edition, Springer/BSP Publication, 2008.
T2. R. L. Sullivan, ***Power System Planning***, Tata McGraw Hill.

Reference Books:

R1. X. Wang and J. R. McDonald, ***Modern Power System Planning***, McGraw-Hill.
R2. T. Gönen, ***Electrical Power Distribution Engineering***, McGraw-Hill.
R3. B. R. Gupta, ***Generation of Electrical Energy***, S. Chand Publication.

Online Resources:

1. https://sites.google.com/a/hindustanuniv.ac.in/nmlindsay/resume/power-system-planning-and-reliability
2. https://slideplayer.com/slide/5291948/

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

CO1	List the objectives of load forecasting and to apply various AI techniques for load forecasting.
CO2	Understand the Reliability concepts and analyze reliability of interconnected generation systems.
CO3	Analyze the reliability of transmission systems considering various factors.
CO4	Explain the expansion planning and capacitor placement problems.
CO5	Design distribution systems & explain distribution system protective scheme and its coordination.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1			2	1	1	2					2	1	1
CO2			1	1	2	1					3	1	
CO3			1	1	2	2						1	
CO4			2	1	2	2					1	1	
CO5			2	1	2	2					1	2	

Type	Code	Power Apparatus Systems	L-T-P	Credits	Marks
PE	18MP2T11		3-0-0	3	100

Objectives	The objectives of this course is to impart knowledge on performance characteristics and dynamics of machine and its stability studies.
Pre-Requisites	Knowledge of Electrical machines, its dynamic equations and modeling of power system components using different software tools is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basis of Idealized machines: Primitive four winding commutator machine, Commutator primitive machine, Complete voltage equation of primitive four winding Commutator machine and its stability studies, Torque dynamics of simple DC machines using the primitive model.	**10 Hours**
Module-2	Three phase induction motor: Transformed equations, and different reference frames theories, Transfer function model, Equivalent circuit diagram.	**8 Hours**
Module-3	Induction Motor problems: Application of equations in primary and secondary reference frame, Short circuit analysis, Transient stability calculations.	**6 Hours**
Module-4	Three phase salient pole synchronous machine: Three phase to two phase transformation theory (Parks transformation), Clerk transformation, and Steady state analysis.	**6 Hours**
Module-5	Synchronous generator short circuit and system faults: Symmetrical and unsymmetrical short circuit analysis, System fault calculations, Sudden load changes.	**6 Hours**
Module-6	Transformer transients: Overcurrent transients, In-rush current in three phase transformer, Primary switching-in of loaded transformers, Over voltages in transformers, Transformer protection against surges.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. B. Adkins and R. G. Harley, ***The General Theory of Alternating Current Machines: Application to Practical Problems***, Springer, 1975.
T2. P. S. Bimbhra, ***General Theory of Electrical Machines***, 5th Edition, Khanna Publishers, 2006.

Reference Books:

R1. P. C. Krause, O. Wasynczuk, S. D. Sudhoff, ***Analysis of Electrical Machines***, IEEE Press, 1995.
R2. I. Boldia and S. A. Nasar, ***Electrical Machine Dynamics***, Macmillan Press, 1992.
R3. C. V. Jones, ***The Unified Theory of Electrical Machines***, Butterworth, London, 1967.

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

CO1	Get a detailed concept of performance characteristics of primitive machine and stability studies.
CO2	Understand the induction motor dynamics in various reference frame.
CO3	Analyze the different operating problems in induction motor and determine the transient stability.
CO4	Understand the transformations of synchronous machine from three phase to two phase dynamics and its stability issues.
CO5	Analyze short circuit and system faults in synchronous generator.
CO6	Estimate over current and over voltage transients in transformer and its protection against surges.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	2					3	2	
CO2	3	2	1	1	2	1					3	1	
CO3	1	3	1	1	2	2					2	1	
CO4	3	2	2	1	2	2					3	2	
CO5	2	3	2	1	2	2					2	1	
CO6	2	1	2	2	2	1					3	2	1

Type	Code	Advanced Micro-Controller Based Systems	L-T-P	Credits	Marks
PE	18MP2T13		3-0-0	3	100

Objectives	The objectives of this course is to enable the students understand the architecture of advanced microcontrollers with their applications and introduce them to FPGA.
Pre-Requisites	Knowledge of electrical & electronics and programming in any language is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic Computer Organization, Accumulator based Processes - Architecture, Memory Organization - I/O Organization.	**6 Hours**
Module-2	Micro-Controllers - Intel 8051, Intel 8056 - Registers, Memories, I/O Ports, Serial Communication, Timers, Interrupts, Programming.	**8 Hours**
Module-3	Intel 8051 – Assembly language programming, Addressing-Operations, Stack & Subroutines, Interrupts - DMA.	**8 Hours**
Module-4	PIC 16F877 - Architecture Programming, Interfacing Memory/ I/O Devices, Serial I/O and data communication.	**8 Hours**
Module-5	Digital Signal Processor (DSP), Architecture – Programming, Introduction to FPGA.	**6 Hours**
Module-6	Microcontroller development for motor control applications, Stepper motor control using micro controller.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. J. F. Wakerly, ***Microcomputer Architecture and Programming***, 1st Edition, John Wiley and Sons, 1981.
T2. R. S. Gaonker, ***Microprocessor Architecture, Programming and Applications with the 8085***, 6th Edition, Penram International Publishing (India), 1994.
T3. J. Morton, ***The PIC Microcontroller: Your Personal Introductory Course***, 3rd Edition, Elsevier, 2005.

Reference Books:

R1. R. Kamal, ***The Concepts and Features of Microcontrollers***, Wheeler Publishing, 2005.
R2. K. J. Ayala, ***The 8051 Microcontrollers***, 3rd Edition, Cengage Learning, 2004.
R3. D. Ibrahim, ***Advanced PIC Microcontroller Projects in C: From USB to RTOS with the PIC18F Series***, 2nd Edition, Elsevier, 2008.
R4. Microship Technology Inc., ***Microchip Datasheets for PIC16F877***, 2013.

P.T.O

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

CO1	Understand the architecture and organization of a microcontroller.
CO2	Understand the operation of different microcontrollers as well as DSP based systems.
CO3	Program a microcontroller or microprocessor using assembly language.
CO4	Aquire insight into the architecture and interfacing of Memory and I/O devices.
CO5	Develop a deep understanding of architecture and programming of DSP.
CO6	Develop microcontroller based motor control applications.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1										1		
CO2	1	1	1								1	1	
CO3	1		2	1		1					1	1	
CO4	1	1	1	2		1	2				1	1	
CO5	1	1	1								1	2	
CO6	3	2	2	1		1	2				2	2	

Type	Code	SCADA System and Applications	L-T-P	Credits	Marks
PE	18MP2T14		3-0-0	3	100

Objectives	The objective of the course is to know the SCADA communication, operations and applications.
Pre-Requisites	Knowledge of communication, automation and power system operation & control is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies.	**8 Hours**
Module-2	Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries SCADA.	**6 Hours**
Module-3	Industries SCADA system components, Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication network, SCADA server, SCADA/HMI Systems.	**8 Hours**
Module-4	SCADA architecture, Various SCADA architectures, Advantages and disadvantages of each system, Single unified standard architecture -IEC 61850.	**8 Hours**
Module-5	SCADA Communication, Various industrial communication technologies, Wired and wireless methods and fiber optics, Open standard communication protocols.	**8 Hours**
Module-6	SCADA Applications: Utility applications, Transmission and Distribution sector operations, Monitoring, Analysis and improvement, Industries - oil, gas and water, Case studies, Implementation, Simulation Exercises.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, 4th Edition, Instrument Society of America Publications, USA, 2009.
T2. G. Clarke and D. Reynders, ***Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems***, 1st Edtion, Newnes Publications, Oxford, UK, 2004.
T3. W. T. Shaw, ***Cybersecurity for SCADA Systems***, PennWell Books, 2006.

Reference Books:

R1. D. Bailey and E. Wright, ***Practical SCADA for Industry***, Newnes Publications, 2003.
R2. M. Wiebe, ***A Guide to Utility Automation: AMR, SCADA, and IT Systems for Electric Power***, PennWell Books, 1999.

Online Resources:

1. https://nptel.ac.in/courses/108106022/8
2. https://electrical-engineering-portal.com/an-introduction-to-scada-for-electrical-engineers-beginners
3. https://www.scribd.com/document/246856029/Study-Material-Forplc-Scada

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

CO1	Acquire knowledge on supervisory control and their applications.
CO2	Understand various architectures of SCADA systems with their advantages and limitations.
CO3	Learn about remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
CO4	Get an overview of single unified standard architecture IEC 61850.
CO5	Understand various SCADA communication like fiber optics and open standard communication protocols.
CO6	Apply the knowledge for applications of SCADA systems on distribution sector and other industries.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	1	1	1	2	1					1	1	
CO2		1			1	1					1	2	1
CO3	3	2	1	1	2	3					2	1	1
CO4		1			1	1					1		
CO5	1	1	1		1	2					1	1	
CO6	2	2	1		1	2					2	1	1

Type	Code	Power Quality	L-T-P	Credits	Marks
PE	18MP2T10		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to the fundamentals of electrical power quality, its effect on cost of electrical power, problems & principles of mitigation, and monitoring & mitigating equipment.
Pre-Requisites	Knowledge of engineering physics, network theory, control systems, electrical machines, and power electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction-power quality-voltage quality-overview of power, Quality phenomena classification of power quality issues, Power quality measures and standards-THD-TIF-DIN-C-message weights, Flicker factor transient phenomena-occurrence of power quality problems, Power acceptability curves-IEEE guides, Standards and recommended practices.	**5 Hours**
Module-2	Harmonics-individual and total harmonic distortion, RMS value of a harmonic waveform, Triplex harmonics, Important harmonic introducing devices, SMPS Three phase power converters-arcing devices saturable devices, Harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.	**8 Hours**
Module-3	Modelling of networks and components under non-sinusoidal conditions, Transmission and distribution systems, Shunt capacitors-transformers, Electric machines, Ground systems loads that cause power quality problems. Power quality problems created by drives and its impact on drive.	**6 Hours**
Module-4	Power factor improvement- Passive Compensation, Passive Filtering. Harmonic Resonance. Impedance Scan Analysis, Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC based on Bilateral Single Phase and Three Phase Converter.	**6 Hours**
Module-5	Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis.	**8 Hours**
Module-6	Introduction to design method based on the use of Lyapunov function. Design and simulation of variable structure adaptive model following control.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. T. Heydt, ***Electric Power Quality***, 2nd Edition, McGraw-Hill Professional, 2007.
T2. M. H. Bollen, ***Understanding Power Quality Problems***, IEEE Press, 2000.

T3. R. C. Dugan, M. F. McGranaghan, S. Santoso, and H. W. Beaty, ***Electrical Power Systems Quality***, 3rd Edition, TMH Education, 2012.

Reference Books:

R1. J. Arrillaga, N. R. Watson, and S. Chen, ***Power System Quality Assessment***, John Wiley & Sons, 2011.
R2. J. Arrillaga, B. C. Smith, N. R. Watson, and A. R. Wood, ***Power System Harmonic Analysis***, 3rd Edition, John Wiley & Sons, 2013.

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

CO1	Understand importance of power quality with power quality issues & standards.
CO2	Understand Harmonics and its sources in power systems.
CO3	Model power systems under non-sinusoidal condition for transient studies.
CO4	Understand and analyze the solutions to mitigate power quality problems.
CO5	Design model reference adaptive systems for power quality problems.
CO6	Design variable structure control for power quality systems.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	2			1				3	2	
CO2	3	2	2	2			1				3	2	
CO3	3	3	3	3							3	3	1
CO4	3	2	3	2			1				3	2	1
CO5	3	3	3	3							3	2	1
CO6	3	3	3	3							3	3	2

Type	Code	AI Techniques	L-T-P	Credits	Marks
PE	18MP2T15		3-0-0	3	100

Objectives	The objective of this course is to learn the basics of Knowledge Representation, Problem Solving, and Learning methods of AI, to understand role of AI in intelligent systems engineering, and to apply computational models for real-life problem solving.
Pre-Requisites	Knowledge of data structures and data management is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Biological foundations to intelligent systems I: Artificial neural networks, Back propagation networks, Radial basis function networks, and recurrent networks.	**8 Hours**
Module-2	Biological foundations to intelligent systems II: Fuzzy logic, inference mechanism in fuzzy logic, introduction to Genetic Algorithm (GA) and fuzzy neural networks.	**7 Hours**
Module-3	Search Methods Basic concepts of graph and tree search; Three simple search methods: breadth-first search, depth-first search, iterative deepening search; Heuristic search methods: best-first search, admissible evaluation functions, hill-climbing search; Optimization and search such as stochastic annealing and genetic algorithm.	**8 Hours**
Module-4	Knowledge representation and logical inference Issues in knowledge representation. Structured representation, such as frames, and scripts, semantic networks and conceptual graphs; Formal logic and logical inference; Knowledge-based system structures & its basic components.	**8 Hours**
Module-5	Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, A study of different learning and evolutionary algorithms, such as statistical learning and induction learning.	**6 Hours**
Module-6	Recent trends in fuzzy logic and knowledge representation.	**5 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Russell and P. Norvig, ***Artificial Intelligence: A Modern Approach***, 3rd Edition, Pearson Education India, 2015.

Reference Books:

R1. N. J. Nilsson, ***Artificial Intelligence: A New Sythesis***, Morgan-Kaufmann, 2003.
R2. G. F. Luger and W. A. Stubblefield, ***Artificial Intelligence: Structures and Strategies for Complex Problem Solving***, 6th Edition, Addison Wesley, 2008.

Online Resources:

1. http://nptel.ac.in/courses/108104049/: NPTEL – E-Learning Courses from IIT & IISc.
2. http://www.princeton.edu/~stengel/MAE345.html: Robotics and Intelligent Systems, Princeton University, New Jersey, USA.

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

CO1	Demonstrate the fundamental principles of intelligent systems.
CO2	Conceive the concepts of Fuzzy inference mechanism, GA, and Fuzzy ANN.
CO3	Explore different techniques to solve artificial intelligence problems by searching.
CO4	Grasp the concepts of various knowledge representation techniques & inference mechanisms.
CO5	Envisage the need of quantifying uncertainty and probabilistic reasoning.
CO6	Apply the fuzzy reasoning and knowledge representation in real-life problem solving.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2		2	1	1	1				2	2	3	2
CO2	3		2	2	2	2				3	3	3	2
CO3	2		3	2	3	1				2	3	3	2
CO4	2		2	1	2	1				1	2	3	2
CO5	2		2	2	2	2				2	2	2	1
CO6	2		2	2	2	3				3	2	2	3

Type	Code	English for Research Paper Writing	L-T-P	Credits	Marks
AC	18MS8T11		2-0-0	0	100

Objectives	The objective of this course is to give learners an exposure to different aspects of research related technical writing and to help them write such matter effectively through practice.
Pre-Requisites	Basic knowledge of English grammar and the ability to read and write using the English language.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on technical writing activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Technical Communication: Differentiating between general and technical writing, purpose of writing, plain English, mechanics of writing, elements of style. Essentials of English Grammar: basic word order, tense forms, reported speech, use of passives, conditionals, concord, clauses, common errors.	**9 Hours**
Module-2	Elements of Writing: Process writing, developing an effective paragraph, qualities of a paragraph, structuring a paragraph, types of essays, writing reports.	**5 Hours**
Module-3	Key Reading Skills: sub-skills of reading, local and global comprehension, types of technical texts, critical analysis of technical texts, note-making, the purpose and importance of literature review, evaluating literature.	**5 Hours**
Module-4	Developing Writing Skills: writing abstracts, technical letters, project reports, elements of proposal writing.	**6 Hours**
Module-5	Research and Writing: The research paper as a form of communication, Writing a review of Literature, developing a hypothesis, formulating a thesis statement, plagiarism issues.	**3 Hours**
	Total	**28 Hours**

Text Books:

T1. C. Ellison, ***McGraw-Hill's Concise Guide to Writing Research Papers***, McGraw-Hills, 2010.
T2. A. Wallwork, ***English for Writing Research Papers***, Springer, 2011.
T3. R. A. Day, ***How to Write and Publish a Scientific Paper***, 7th Edition, Greenwood, 2011.

Reference Books:

R1. R. Goldbort, ***Writing for Science***, Yale University Press, 2006.
R2. N. J. Higham, ***Handbook of Writing for the Mathematical Sciences***, 2nd Edition, SIAN, 1998.
R3. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2014.

P.T.O

Online Resources:

1. https://msu.edu/course/be/485/bewritingguideV2.0.pdf: Michigan State University Press, USA, Technical Writing Guide, 2007.
2. http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf: Sentence Structure of Technical Writing, Nicole Kelley, MIT, USA, 2006.
3. http://www.inf.ed.ac.uk/teaching/courses/pi/2017_2018/slides/Technical-Writing-Basics.pdf: Notes from Pocketbook of Technical Writing for Engineers and Scientists by Leo Finkelstein, NY, 2007.
4. https://www.shs-conferences.org/articles/shsconf/pdf/2016/04/shsconf_erpa2016_01090.pdf: A need analysis of technical writing skill of engineering students in India, JCK Evangeline & K. Ganesh, DOI: 10.1051/ shsconf/20162601090, 2016

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

CO1	Understand the importance and application of technical communication and apply essentials of English grammar to make research writing effective.
CO2	Apply the elements of technical writing to produce effective research papers.
CO3	Develop critical reading and analysis skills of technical research papers and texts.
CO4	Develop the ability to write technical articles and effectively present the ideas.
CO5	Develop research acumen by understanding the key skills of research.

Program Outcomes Relevant to the Course:

PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						3	1	1	3	3	1	2	3
CO2						3			3	3	1	2	3
CO3						3	1	1	3	3	2	2	3
CO4						2		1	3	3	2	2	3
CO5						2	1	3	3	3	2	2	3

Type	Code	Power Systems Lab-II	L-T-P	Credits	Marks
PC	18MP1L03		0-0-4	2	100

Objectives	The objective of this laboratory course is to introduce conventional electromagnetic relays and conduct experiments on various fault analysis along with their transient & dynamic studies.
Pre-Requisites	Knowledge on power systems & power system protection is required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Demonstration shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Determination of positive, negative & zero sequence reactance of an alternator to make analysis of various faults in an unloaded alternator.
2	Study of an over current & 3-ϕ differential relay.
3	Study of various lightning arresters.
4	Fault studies for a given power system.
5	Obtain swing curve for given power system when a fault is cleared.
6	Calculation of fault clearing time for a (i) SLG fault and (ii) 3-phase fault
7	Computation of fault level at different buses in a power system for a (i) SLG fault and (ii) 3-phase fault
8	Calculation of L-index for determining most sensitive bus in a power system. Also obtain the followings: (i) Plotting of PV curve, (ii) Calculation of centroid
9	Impact on voltage with variation of wind integration in a power system.

Text Books:

T1. H. Saadat, ***Power System Analysis***, 2nd Edition, Tata McGraw-Hill, 2002.
T2. J. J. Grainger & W. D. Stevenson, ***Power System Analysis***, 1st Edition, McGraw-Hill, 2017.
T3. A. G. Phadke and J. S. Thorp, ***Computer Relaying for Power Systems***, Wiley/Research Studies Press, 2009.

Reference Books:

R1. L. P. Singh, ***Advanced Power System Analysis and Dynamics***, 6th Edition, New Age International, 2012.
R2. T. K. Nagsarkar & M. S. Sukhija, ***Power System Analysis***, Oxford University Press, 2007.
R3. S. R. Bhide, ***Digital Power System Protection***, PHI Learning Pvt. Ltd. 2014.

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

CO1	Learn the importance of Relays, Lightning arresters & various protective elements.
CO2	Apply Mathematical approach towards protection.

Cont'd...

CO3	Learn to develop various Protection algorithms.
CO4	Lear the basic requirements of digital protection.
CO5	Learn transient & dynamic studies of a power system.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1									2	2	1
CO2	3	1	3	3	3					1	2	2	1
CO3	3	2	3	2	1					1	3	1	2
CO4	3	1	1								2	1	2
CO5	3	3	3	1	1	1				1	2	2	2

Type	Code	Power Electronics Applications to Power Systems Lab	L-T-P	Credits	Marks
PC	18MP1L04		0-0-4	2	100

Objectives	The objective of this laboratory course is to introduce the students to power electronics control to power systems, give practical exposure to simulated analysis of different aspects of power electronics in power systems like drives, FACTs control in power system, and power quality problems.
Pre-Requisites	Knowledge and concepts of converter topology, analysis of PWM switching schemes, control theories and knowledge of MATLAB are required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Demonstration shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of single-phase AC voltage regulator with resistive and inductive loads.
2	Study of single phase cyclo-converter.
3	Study of triggering of (i) IGBT (ii) MOSFET (iii) power transistor.
4	Study of Chopper Fed DC Motor drive.
5	PWM inverter fed three phase induction motor control using software.
6	VSI/CSI fed induction motor drive analysis using software.
7	Study of V/f control operation of three phase induction motor.
8	Study of static VAR compensator (SVC).
9	Study and analysis of STATCOM using software.
10	Study the operation and control of Unified Power flow Controller (UPFC).
11	Study the single-phase series-resonant inverter.
12	Study the ZCS and ZVS-resonant converter using software.
13	Study MOSFET/IGBT based single-phase bridge inverter.
14	Regenerative/ Dynamic breaking operation for DC motor study using software.
15	Regenerative/ Dynamic breaking operation for AC motor study using software.
16	PLC based AC/DC motor control operation.
17	Study of speed control of IM by using Kramer drive method.
18	Study the vector control of IM drive using DSP 2812 controller.
19	Study of Thyristor-Controlled Series Compensator (TCSC).
20	Study of active power filter in distributed system for power quality improvement.

Text Books:

T1. N. Mohan, T. M. Undeland, and W. P. Robbins, ***Power Electronics: Converters, Applications, and Design***, 3rd Edition, John Wiley & Sons, 2003.

T2. M. H. Rashid, ***Power Electronics: Circuits, Devices and Applications***, 4th Edition, Pearson Education, 2017.

Reference Books:

R1. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st Edition, Pearson Education, 2005.
R2. K. R. Padiyar, ***FACTS Controllers in Power Transmission and Distribution***, 2nd Edition, New Age International Publishers, 2016.

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

CO1	Design various PE converters, voltage controllers, triggering circuit of different semiconductor switches and resonant inverters.
CO2	Analyze the control of various drives and its performance analysis.
CO3	Learn the active and reactive power flow control in power system.
CO4	Obtain a deeper understanding of the needs for static compensators.
CO5	Develop different control strategies used for compensation in power system.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1				1	3	2	2
CO2	2	3	2	1	1	2				2	2	2	2
CO3	2		2	2	1	1				2	3	2	2
CO4	3		2	2	1	1				1	3	2	2
CO5	3		2	1	1	1				1	3	2	2

Part II

2nd Year M.Tech. (EEE) (Power Systems)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PE	18MP2T**	Professional Elective-V	3	0	0	3	0	0
OE	18MA3T**	Open Elective	3	0	0	3	0	0
PRACTICAL									
PJ	18MP7L01	Thesis (Part - I) & Seminar	0	0	20	0	0	10
		SUB-TOTAL	**6**	**0**	**20**	**6**	**0**	**10**
		TOTAL	**26**			**16**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - V
18MP2T16	Power System Transients
18MP2T17	FACTS and Custom Power Devices
18MP2T18	Industrial Load Modeling & Control
18MP2T19	Dynamics of Linear Systems
	Open Elective
18MA3T01	Business Analytics
18MA3T02	Industrial Safety
18MA3T03	Operations Research
18MA3T04	Cost Management of Engg. Projects
18MA3T05	Composite Materials
18MA3T06	Waste to Energy

Semester IV								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL								
PJ	18MP7L02	Thesis (Part-II) & Seminar	0	0	32	0	0	16
		SUB-TOTAL	**0**	**0**	**32**	**0**	**0**	**16**
		TOTAL	**32**			**16**		

Type	Code	Power System Transients	L-T-P	Credits	Marks
PE	18MP2T16		3-0-0	3	100

Objectives	The objective of the course is to provide an overview of various causes of transients, their effects on power system operations and methods adopted to protect power system from harmful effects of transients.
Pre-Requisites	Elementary idea of Laplace transformation, Z transformation, basics of various components & protective devices used in power systems, and basic knowledge of power system analysis is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fundamental circuit analysis of electrical transients, Laplace transformation for solving simple switching transients, Damping circuits: Abnormal switching transients, Three phase circuits and transients, Computation of power system transients.	**8 Hours**
Module-2	Principle of digital computation: Matrix method of solution, Modal analysis, Z-transform: Computation using EMTP, Lightning, Switching and temporary over voltages, Physical phenomena of lightning.	**8 Hours**
Module-3	Interaction between lightning and power system, Influence of tower footing resistance and earth resistance, Switching: Short line or Kilometric fault, Energizing transients, Closing and reclosing of lines, Line dropping, Load rejection, Over voltage induced by faults.	**8 Hours**
Module-4	Switching of HVDC line, Travelling wave on transmission lines, Circuits with distributed parameters, Wave equation, Reflection, Refraction, Behavior of traveling waves at the line terminations, Lattice diagrams: Attenuation and distortion, Multi-conductor system, Velocity wave.	**8 Hours**
Module-5	Insulation co-ordination: Principle of insulation co-ordination in air insulated substation (AIS) and gas insulated substation (GIS), Co-ordination between insulation and protection level, Statistical approach.	**6 Hours**
Module-6	Protective devices, Protection of system against over voltages, Lightning arrester, Substation earthing.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. A. Greenwood, ***Electric Transients in Power System***, 2nd Edition, Willy & Sons, 2010.
T2. C. S. Indulkar, D. P. Kothari, and K. Ramalingam, ***Power System Transients – A Statistical Approach***, 2nd Edition, PHI Learning, 2010.

Reference Books:

R1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th Edition, Tata McGraw-Hill, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108105104/12
2. https://nptel.ac.in/courses/108104048/27
3. https://nptel.ac.in/courses/108104013/33

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

CO1	Understand basic concepts and various causes of power system transients such as lightning, switching and their effects on critical system parameters.
CO2	Formulate the mathematical model for detail analysis of power system transients.
CO3	Realize the effect of lightning on Power systems and study various causes of temporary over voltage (TOV).
CO4	Visualize the effect of travelling waves in transmission lines and their characteristics.
CO5	Learn the insulation co-ordination to determine the insulation strength of equipment.
CO6	Analyze the protection schemes adopted to protect power system against surges or transients.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2		2	1		3					2	1	
CO2	2		2	2		2					3	1	1
CO3	2		1	1	1	3					2	1	
CO4	2		1	1	1	3					2	2	1
CO5	1		1	2	1	3					2	1	
CO6	1	1	1	2	1	1					2	1	

Type	Code	FACTS & Custom Power Devices	L-T-P	Credits	Marks
PE	18MP2T17		3-0-0	3	100

Objectives	The objective of this course is to learn the active & reactive power flow control in power systems, understand the need for static compensators and develop the different control strategies used for compensation.
Pre-Requisites	Knowledge of power systems, power electronics, and electrical machines is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities and case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Reactive power flow control in Power Systems, Control of dynamic power unbalances in Power Systems – 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.	**8 Hours**
Module-2	Static versus passive VAR compensator, Static shunt compensators – SVC and STATCOM, Operation and control of TSC, TCR and STATCOM, Compensator Control, Comparison between SVC and STATCOM.	**8 Hours**
Module-3	Static synchronous series compensators and their Control, Static series compensation – GCSC, TSSC, TCSC, TSSC, SSSC; Static voltage and phase angle regulators, TCVR & TCPAR Operation and Control, Applications.	**8 Hours**
Module-4	SSR and its damping Unified Power Flow Controller – Circuit Arrangement, Operation and control of UPFC, Basic Principle of P and Q control, Independent real and reactive power flow control – Applications.	**7 Hours**
Module-5	Introduction to interline power flow controller; Modelling and analysis of FACTS Controllers, Simulation of FACTS controllers, Power quality problems in distribution systems, harmonics, loads that create harmonics, harmonic propagation, series and parallel resonances mitigation of harmonics using passive and active filtering (shunt, series & hybrid) and their control.	**7 Hours**
Module-6	Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners; IEEE standards on power quality.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. K. R. Padiyar, ***FACTS Controllers in Power Transmission and Distribution***, 2nd Edition, New Age International, 2016.

T2. N. G. Hingorani and L. Gyugyi, ***Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems***, (Wiley-IEEE Press) Standard Publishers & Distributors, 2001.

Reference Books:

R1. X. P. Zhang, C. Rehtanz, and B. Pal, ***Flexible AC Transmission Systems – Modelling and Control***, Springer Verlag, 2006.
R2. K. S. Sureshkumar and S. Ashok, ***FACTS Controllers & Applications***, E-book Edition, Nalanda Digital Library, NIT Calicut, 2003.
R3. G. T. Heydt, ***Power Quality***, McGraw-Hill Professional, 2007.
R4. T. J. E. Miller, ***Static Reactive Power Compensation***, 1st Edition, John Wiley & Sons, 1982.

Online Resources:

1. https://nptel.ac.in/courses/108107114/
2. https://www.electronicshub.org/flexible-ac-transmission-systemfacts/

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

CO1	Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
CO2	Learn various Static VAR shunt Compensation Schemes like Thyristor controlled reactor/capacitor, Static compensator and their control approaches.
CO3	Learn various Static VAR series Compensation Schemes like Thyristor / GTO controlled capacitor, Static Synchronous series compensator along with their control techniques and analyse the role of phase angle and voltage regulators in power systems.
CO4	Analyse the effect of SSR in power system and objectives of combined series-shunt FACT controller (UPFC) along with its various control techniques.
CO5	Analyse and model combined series-series FACT controller (IPFC) and various power quality problems along with their mitigation techniques using filters.
CO6	Explore the role of power line conditioners on various power quality problems and IEEE standards on power qualities.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2			1	1					3	1	
CO2	3	3	1	1	2	3					2	1	
CO3	3	3	1	1	2	3					2	1	1
CO4	3	3	1	1	3	3	1			1	3	2	1
CO5	3	3	1	1	3	3	1			1	2	1	1
CO6	2	1	1		1	2	1			1	2	1	1

Type	Code	Industrial Load Modeling & Control	L-T-P	Credits	Marks
PE	18MP2T18		3-0-0	3	100

Objectives	The objective of the course is to understand basic concepts to energy demand scenario, modelling of load demand, electricity pricing models, and study reactive power management in industries.
Pre-Requisites	Knowledge of power distribution systems, power electronics & drives, and control Engineering is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving & case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Electric Energy Scenario: Demand Side Management, Industrial Load Management, Load Curves, Load Shaping Objectives, Methodologies, Barriers, Classification of Industrial Loads, Continuous and Batch processes, Load Modeling.	**8 Hours**
Module-2	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.	**8 Hours**
Module-3	Reactive power management in industries, Application of filters for energy saving in industries.	**8 Hours**
Module-4	Cooling and heating loads, Load profiling, Modeling, Cool storage, Types, Control strategies, Optimal operation, Problem formulation, Case studies.	**8 Hours**
Module-5	Captive power units, Operating and control strategies, Power Pooling, Operation model, Energy banking, Industrial Cogeneration.	**6 Hours**
Module-6	Selection of Schemes, Optimal Operating Strategies, Peak load saving, Constraints in Problem formulation, Case studies, Integrated Load management for Industries.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. C. O. Bjork, ***Industrial Load Management – Theory, Practice and Simulations***, Elsevier, 1989.
T2. I. J. Nagarath and D. P. Kothari, ***Modern Power System Engineering***, 4th Edition, Tata McGraw-Hill, 1995.

Reference Books:

R1. C. W. Gellings and S. N. Talukdar, ***Load Management Concepts***, IEEE Press, pp. 3–28, 1986.
R2. Y. Manichaikul and F. C. Schweppe, ***Physically Based Industrial Load***, IEEE Trans. on PAS, April 1981.
R3. H. G. Stoll, ***Least Cost Electricity Utility Planning***, Wiley Interscience Publication, USA, 1989.
R4. IEEE Bronze Book, ***Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities***, IEEE Inc, USA, 1995.

Online Resources:

1. http://nptel.ac.in/courses/108105067/15
2. https://en.wikipedia.org/wiki/Industrial_control_system
3. http://www.pacontrol.com/download/ProcessControlFundamentals.pdf

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

CO1	Know the load control techniques in industries and their applications.
CO2	Learn different factors in electricity pricing, types of industrial processes, and optimize the process using several optimization tools.
CO3	Apply load management studies to reduce demand of electricity during peak time.
CO4	Apply different energy saving opportunities in different industries.
CO5	Learn about the various aspects of self-generation of power by the industries and the concept of load sharing.
CO6	Classify the operating strategies of the industries depending on the management, monitoring, control and protection of load.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3	1	1	2	1				2	1	
CO2	2	1	3	2							3		1
CO3	1	1	2	1		1	2				2	1	
CO4	2	2	2	2	2						2	1	
CO5	2	3	3	2	1	2	1				2	1	1
CO6		1	2	2	1	1	1					1	1

Type	Code	Dynamics of Linear Systems	L-T-P	Credits	Marks
PE	18MP2T19		3-0-0	3	100

Objectives	The objective of this course is to perform analysis & design of linear systems in continuous as well as discrete domain, get an insight to controller design for stability analysis and implementation in software domain.
Pre-Requisites	Knowledge of Mathematics, linear control systems and their analysis in time & frequency domains is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	State Variable Analysis & Design: Introduction, Concepts of State, State Variables and State Model (of continuous time systems), State Model of Linear Systems, State Model for Single-Input-Single-Output Linear Systems, Linearization of the State Equation; State Models for Linear Continuous–Time Systems: State Space Representation using Physical Variables, Phase variable formulations for transfer function with poles and zeros, State space Representation using Canonical Variables, Derivation of Transfer Function for State Model; Diagonalization: Eigenvalues and Eigenvectors; Solution of State Equations: Properties of the State Transition Matrix, Computation of State Transition Matrix based on the Cayley-Hamilton theorem, Sylvester's Expansion theorem.	**12 Hours**
Module-2	Concepts of Controllability and Observability, Effect of Pole zero Cancellation in Transfer Function; Stability improvement by state feedback, Pole Placement Design, Ackerman's Formula, Full-order and reduced order state observers; Separation Principle and state feedback with integral control; Servo Design for analysis of linear time varying systems.	**8 Hours**
Module-3	Introduction of Liapunov Function, Limit Cycles, Basic Liapunov Stability Theorems, Direct Method of Liapunov and the linear systems.	**6 Hours**
Module-4	State Variables and Linear Discrete–Time Systems: State Models from Linear Difference Equations / z-transfer Functions, Solution of State Equations (Discrete Case), Controllability and Observability of discrete systems, Linear Transformation of State Vector (Discrete-Time Case), Derivation of z-Transfer Function from Discrete-Time State Model.	**8 Hours**
Module-5	State feedback of linear discrete time systems, Stability Analysis using Lypunov method; State feedback of linear discrete time systems, Eigenvalue assignment by State Feedback, Design of state observers; Tutorial Problems in software domain.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. K. Ogata, ***Modern Control Engineering***, 5th Edition, Prentice Hall Inc., 2010.
T2. K. Ogata, ***State Space Analysis of Control Systems***, 4th Edition, Prentice Hall Inc.,1967.
T3. M. Gopal, ***Digital Control and State Variable Methods***, 3rd Edition, Tata McGraw-Hill, 2009.

Reference Books:

R1. T. Kailath, ***Linear Systems***, 1st Edition, Prentice Hall Inc., 1980.
R2. C. T. Chen, ***Linear System Theory and Design***, 3rd Edition, Holt Rhinehart & Wintson, 1984.

Online Resources:

1. https://nptel.ac.in/courses/108103008/28
2. http://web.mit.edu/2.14/www/Handouts/StateSpace.pdf
3. https://www.electrical4u.com/state-space-analysis-of-controlsystem/
4. https://www.coursera.org/lecture/nonlinear-spacecraft-attitude-control/3-lyapunov-stability-of-linear-system-bsEa8
5. https://en.wikibooks.org/wiki/Control_Systems/MATLAB
6. https://www.mathworks.com/videos/state-space-models-part-2-control-design-100816.html

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

CO1	Learn state space modelling, analysis & design for application to engineering problems in a global perspective.
CO2	Design various basic controllers for stability of linear closed loop systems using different methods like state feedback controller using pole placement technique.
CO3	Understand the non-linear liapunov method and stability analysis for linear systems along with basic physical non-linearities.
CO4	Perform mapping between continuous and discrete system and analyse its controllability & observability.
CO5	Learn stability analysis for discrete systems and can utilize modern software tools for analysis & design of the same.

Program Outcomes Relevant to the Course:

PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1		3	2	3	2	2	1			1	3	2	1
CO2		3	3	2	3	2	2			1	2	2	1
CO3			2	1	2	1					3	1	
CO4		3	2	2	2	2	1			1	2	1	1
CO5		3	3	1	2		2				3	1	

Type	Code	Business Analytics	L-T-P	Credits	Marks
OE	18MA3T01		3-0-0	3	100

Objectives	The objective of this course is to gain understanding of the role of business analytics within an organization, formulation of decision making problems and solving those problems through statistical and data mining techniques.
Pre-Requisites	Basic knowledge of Statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities and real-life applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Business Analytics**: Evolution and scope of business analytics, Relationship of business analytics and organization, Competitive advantages of business analytics, Overview of problem formulation, data collection, model selection and problem solving	**5 Hours**
Module-2	**Data Exploration**: Visualizing data, Measures of location, dispersion and association, Summarization of grouped and categorical data	**5 Hours**
Module-3	**Descriptive Analytics**: Common probability distributions, Sampling and parameter estimation, Confidence intervals, Hypothesis testing, Analysis of variance.	**12 Hours**
Module-4	**Predictive Analytics**: Regression analysis, Forecasting models for stationary time series and time series with linear trend, Data classification using k-nearest neighbor, logistic regression and association rule mining.	**12 Hours**
Module-5	**Prescriptive Analytics**: Formulating decision problems, Creating decision strategies, Using decision trees and linear optimization, Developing information policy, Ensuring data quality, Measuring contribution of business analytics.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. J. Schniederjans, D. G. Schniederjans, and C. M. Starkey, ***Business Analytics: Principles, Concepts, and Applications***, 1st Edition, Pearson FT Press, 2014.
T2. J. Evans, ***Business Analytics***, 2nd Edition, Pearson Education, 2016.

Reference Books:

R1. J. Cadle, M. Eva, K. Hindle, D. Paul, C. Rollason, P. Turner, and D. Yeates, ***Business Analysis***, 3rd Edition, BCS, The Chartered Institute for IT, 2014.
R2. W. Winston, ***Business Analytics: Data Analysis & Decision Making***, 5th Edition, South-Western College Publishing, 2014.
R3. R. Bartlett, ***A Practitioner's Guide To Business Analytics: Using Data Analysis Tools To Improve Your Organization's Decision Making And Strategy***, 1st Edition, McGraw-Hill Professional, 2013.

Online Resources:

1. https://nptel.ac.in/courses/110105089/
2. https://nptel.ac.in/courses/110107092/
3. http://mgencer.com/files/BA/BA464-index.html: Business Analytics Lecture Notes

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

CO1	Demonstrate broader knowledge of the role and importance of data analytics.
CO2	Explore and visualize data.
CO3	Fit data to specific distributions, estimate parameters and test their hypotheses.
CO4	Demonstrate the ability to use technical skills in predictive analytics.
CO5	Translate data into clear, actionable insights using prescriptive modeling.

Program Outcomes Relevant to the Course:

PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1				1	2					1	1	2	
CO2					2	1	2			2	1	2	1
CO3					2	2		1		1	2	1	1
CO4				2	2	2	1			1	1	1	1
CO5				2	2	2	1			1	1	1	1

Type	Code	Industrial Safety	L-T-P	Credits	Marks
OE	18MA3T02		3-0-0	3	100

Objectives	The objective of this course is to provide knowledge of safety, risk management, laws, hazard analysis & assessment, and topics pertinent to industrial operations and workplace safety.
Pre-Requisites	Basic ideas of industrial safety and regulations would be helpful.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on case studies & real-world examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Industrial Safety**: Definition, safety policy, organizational safety, accident, causes, types, results and control; Safety concerning wash rooms, drinking water, electrical safety; Cleanliness, pressure vessels, safety color codes, fire prevention and firefighting, equipment and methods.	**8 Hours**
Module-2	**Fundamentals of Maintenance Engineering**: Definition and aim of maintenance engineering; Primary and secondary functions and responsibility of maintenance department; Types of maintenance and applications of tools used for maintenance, Maintenance costs, Service life of equipment, Periodic inspection-concept, cleaning and repairing schemes, repair complexities and its use, definition, need, steps and advantages of preventive maintenance, Steps/procedures for periodic and preventive maintenance.	**8 Hours**
Module-3	**Wear & Corrosion and their Prevention**: Wear – types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general layouts; Corrosion – definition, principle and factors affecting corrosion, Types of corrosion, corrosion prevention methods.	**8 Hours**
Module-4	**Hazard, Risk Issues and Hazard Assessment**: Introduction to hazards, hazard monitoring-risk issue, Hazard assessment, procedure, methodology; Safety audit, checklist analysis, what-if analysis, safety review, preliminary hazard analysis (PHA), Hazard analysis (HAZAN), hazard operability studies (HAZOP), Types of Hazards, causes and preventive steps/procedures.	**9 Hours**
Module-5	**Regulations for Health, Safety and Environment**: Factories act and rules -– Workmen's Compensation Act; Indian Explosives Act – Gas cylinder rules -– SMPV (Static and Mobile Pressure Vessels) Act – Indian Petroleum Act and Rules; Environmental Protection Act (EPA); Manufacture, Storage and Import of Hazardous Chemical rules 1989, Indian Electricity Act and Rules, Overview of OSHA (US), OHSAS 18000 and ISO 14000 (India); Representative case studies.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. K. Jain and S. S. Rao, ***Industrial Safety, Health and Environment Management Systems***, 4th Edition, Khanna Publishers, 2017.

Reference Books:

R1. L. M. Deshmukh, ***Industrial Safety Management***, 1st Edition, Tata McGraw-Hill, 2005.
R2. A. Gupta, ***Industrial Safety and Environment***, 1st Edition, Laxmi Publications, 2006.
R3. R. C. Mishra and K. Pathak, ***Maintenance Engineering and Management***, 2nd Edition, Prentice-Hall India, 2012.
R4. H. P. Garg, ***Industrial Maintenance***, 4th Edition, S. Chand & Co., 2012.

Online Resources:

1. https://nptel.ac.in/courses/110105094/
2. https://nptel.ac.in/courses/112107143/40
3. https://nptel.ac.in/courses/103106071/
4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-863j-system-safety-spring-2016/lecture-notes/MIT16_863JS16_LecNotes7.pdf

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

CO1	Apply concepts of safety policies used to prevent accidents and recognize hazards.
CO2	Understand fundamentals of maintenance engineering and applications.
CO3	Apply concepts regarding wear, corrosion and their prevention in industrial settings.
CO4	Understand hazards, risk issues and hazard assessment methods.
CO5	Become familiar with regulations for health, safety and environment.

Program Outcomes Relevant to the Course:

PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1	1		1	1		1	1
CO2						2	1		2	2		1	1
CO3						1	1		1	1	1	2	2
CO4						2	1		2	2	1	2	2
CO5						2	1		2	2	1	2	2

Type	Code	Operations Research	L-T-P	Credits	Marks
OE	18MA3T03		3-0-0	3	100

Objectives	The objective of this course is to know the methods to optimize the processes, algorithms, solve large-scale industrial optimization problems, and implement the solution processes.
Pre-Requisites	Basic concepts of multivariable functions, maxima & minima, matrices, probability theory and capability of understanding algorithmic computation are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Concept of OR, Formulation of Linear Programming models, Graphical Solution, Simplex technique, Solution of artificial variables of LPP.	**8 Hours**
Module-2	Revised Simplex method, Duality theory, Dual Simplex method, Sensitivity Analysis, Integer Programming.	**8 Hours**
Module-3	Non-linear programming problem: Lagrange's method , Kuhn Tucker condition, Quadratic Programming problem, Dynamic Programming: Forward and Backward Recursion, Knapsack/cargo loading model, solution by Bellman's Optimality principle.	**10 Hours**
Module-4	Game theory: Two Person Zero sum game, Games with and without Saddle point, graphical method and LPP model, Scheduling a project with CPM, Scheduling a project with PERT, Time-cost trade offs.	**8 Hours**
Module-5	Queuing model, Birth and death process, Single Server Models, Multi Server Models, non-exponential models; Deterministic Inventory model, continuous and periodic review models.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. H. A. Taha, ***Operations Research: An Introduction***, 8th Edition, Pearson Education, 2007.
T2. F. S. Hiller and G. J. Lieberman, ***Introduction to Operations Research***, 7th Edition, McGraw-Hill Education, 2001.

Reference Books:

R1. K. Swarup, P. K. Gupta, and M. Mohan, ***Operations Research***, 9th Edition, S. Chand & Sons, 2008.
R2. J. K. Sharma, ***Operations Research Theory and Application***, 5th Edition, MacMillan India, 2013.
R3. W. L. Winston, ***Operations Research Application and Algorithm***, 4th Edition, Cengage Learning, 2004.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/111105039/
2. https://nptel.ac.in/courses/108104112/
3. https://nptel.ac.in/courses/111105100/
4. https://nptel.ac.in/courses/105108127/
5. https://nptel.ac.in/courses/106108056/
6. https://nptel.ac.in/courses/108103108/

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

CO1	Understand and apply simplex method to solve a linear programming problem.
CO2	Apply post optimal analysis methods of a LPP.
CO3	Apply dynamic programming methods to solve problems.
CO4	Understand and apply the concepts of game theory and network analysis in decision making.
CO5	Understand and use queuing and inventory models.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO2	Design the modern electric machines, drives, power converters, and control circuits for specific applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO4	Solve the problems which need critical and independent thinking to show reflective learning.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	2	2	3						2	1	1
CO2	3	1	3	3	3						2	1	1
CO3	2	2	3	2	3						3	2	1
CO4	3	2	3	2	3						3	2	1
CO5	3	2	3	2	3						3	2	1

Type	Code	Cost Management of Engineering Projects	L-T-P	Credits	Marks
OE	18MA3T04		3-0-0	3	100

Objectives	The objective of this course is to provide knowledge of cost estimation, cost control, pricing, break-even analysis & budget preparation for engineering projects, and introduce use of quantitative methods, model formulation & applications for solving business decision problems.
Pre-Requisites	Basic knowledge in Mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Objectives of a Costing System; Inventory valuation and control; Creation of a Database for operational control; Provision of data for Decision-Making.	**7 Hours**
Module-2	Project: meaning, different types, why to manage, cost overruns centres; Various Stages of Project Execution: conception to commissioning; Project execution as conglomeration of technical and nontechnical activities; Detailed Engineering activities; Pre project execution main clearances and documents Project team: Role of each member; Importance Project site: Data required with significance; Project contracts, Types and contents; Project execution, Project cost control, Bar charts and Network diagrams, Project commissioning: mechanical and process.	**8 Hours**
Module-3	Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis; Various decision-making problems; Standard Costing and Variance Analysis.	**9 Hours**
Module-4	Pricing strategies: Pareto Analysis, Target costing, Life Cycle costing, Costing of service sector, Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints; Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis; Budgetary Control, Flexible Budgets, Performance budgets, Zero-based budgets; Measurement of Divisional profitability pricing decisions including transfer pricing.	**10 Hours**
Module-5	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Lal, ***Advanced Management Accounting: Text, Problems and Cases***, 4th Edition, S. Chand Publication, 2016.
T2. A. K. Bhattacharya, ***Principles & Practices of Cost Accounting***, 3rd Edition, PHI, 2010.
T3. N. D. Vohra, ***Quantitative Techniques in Management***, 3rd Edition, Tata McGraw-Hill, 2007.

Reference Books:

R1. C. T. Horngren, S. M. Datar, and M. V. Rajan, ***Cost Accounting: A Managerial Emphasis***, 14th Edition, Prentice Hall of India, 2011.
R2. M. C. Shukla, T. S. Grewal, and M. P. Gupta, ***Cost Accounting: Texts and Problems***, 1st Edition, S Chand & Company, 2007.
R3. R. Panneerselvam, ***Production and Operations Management***, 3rd Edition, PHI, 2012.
R4. M. Y. Khan and P. K. Jain, ***Management Accounting***, 7th Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://www.scribd.com/doc/78419405/Strategic-Cost-Analysis
2. https://www.accountingtools.com/articles/what-is-inventory-valuation.html
3. http://www.umsl.edu/~sauterv/analysis/488_f02_papers/ProjMgmt.html
4. http://cost-edu.blogspot.com/p/basic-cost-concepts.html
5. https://www.imanet.org.cn/uploads/resource/2015-11/1447060485-6834.pdf
6. http://www.interventions.org/pertcpm/

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

CO1	Understand the concept of cost accounting and its application in evaluating engineering project.
CO2	Execute the project as per the plan and control the project execution cost.
CO3	Asses how cost-volume-profit is related and uses CVP analysis as a planning and decision making aid.
CO4	Price the products based on different pricing technique.
CO5	Understand the mathematical tools that are needed to solve optimization problems.

Program Outcomes Relevant to the Course:

PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1			1	1	1	1	1
CO2								1		1			1
CO3						1		1		1		1	1
CO4						1			1	1		2	1
CO5								1	1	1		1	1

Type	Code	Composite Materials	L-T-P	Credits	Marks
OE	18MA3T05		3-0-0	3	100

Objectives	The objective of this course is to classify, manufacturing, physical & mechanical properties and applications of a range of composite materials, and understand the mechanisms of composite deformation and fracture.
Pre-Requisites	Knowledge on materials science, metallurgy and mechanics of solids is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definition, Classification and Characteristics of Composite materials, Advantages and application of composites, Functional requirements of reinforcement and matrix, Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance, Properties (mechanical, transport, thermal, etc.).	**8 Hours**
Module-2	**Reinforcements**: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers; Properties and applications of whiskers, particle reinforcements, Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures, Isostrain and Isostress conditions.	**8 Hours**
Module-3	**Manufacturing of Metal Matrix Composites**: Casting -– Solid State diffusion technique, Cladding – Hot isostatic pressing, Properties and applications; Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration — Liquid phase sintering; Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving, Properties and applications.	**9 Hours**
Module-4	**Manufacturing of Polymer Matrix Composites**: Preparation of moulding compounds and prepregs (hand layup method, Autoclave method, Filament winding method, Compression moulding, Reaction injection moulding), Properties and applications.	**8 Hours**
Module-5	**Failure of Composites**: Fracture modes in composites, Laminar Failure Criteria – strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure, Laminate first play failure-insight strength; Laminate strength – ply discount truncated maximum strain criterion, stress concentrations.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. W. D. Callister and D. G. Rethwisch, ***Materials Science and Engineering - An introduction***, 10th Edition, Wiley, 2014.
T2. K. K. Chawla, ***Composite Materials: Science and Engineering***, 3rd Edition, Springer, 2012.

Reference Books:

R1. R. F. Gibson, ***Principles of Composite Materials Mechanics***, 2nd Edition, CRC Press, 2007.
R2. B. Harris, ***Engineering Composite Materials***, 2nd Edition, Institute of Metals, 1999.
R3. R. W. Cahn, ***Material Science and Technology, Vol 13 -– Composites***, VCH, West Germany.

Online Resources:

1. https://nptel.ac.in/downloads/112104168/
2. http://www.issp.ac.ru/ebooks/books/open/Composites_and_Their_Properties.pdf
3. https://nptel.ac.in/courses/Webcourse-contents/IIScBANG/Composite%20Materials/pdf/Lecture_Notes/LNm7.pdf
4. https://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/Composite%20Materials/pdf/Teacher_Slides/mod2.pdf

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

CO1	Classify and know the properties & applications of composite materials.
CO2	Identify various reinforcing agents and mechanical behavior of composites.
CO3	Know the various manufacturing techniques used in development of metal matrix composites and their applications.
CO4	Recognize the various manufacturing techniques used in development of polymer matrix composites and their applications.
CO5	Understand the various fracture and failures modes of composite materials.

Program Outcomes Relevant to the Course:

PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1		1	1	1	1		
CO2						1		1	1	1		1	1
CO3						1		1	1	1	1		1
CO4						1		1	1	1		1	1
CO5						1		1	1	1	1	1	1

Type	Code	Waste to Energy	L-T-P	Credits	Marks
OE	18MA3T06		3-0-0	3	100

Objectives	The objective of the course is to provide exposure to working principles of waste to energy schemes, their implementation & current practices, and understand the energy conversion technologies of biomass resources.
Pre-Requisites	Knowledge of engineering chemistry, engineering Physics, Thermodynamics environmental science, basic electrical engineering.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on recent trends & technologies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Energy from Waste: Classification of waste as fuel, Agro based, Forest residue, Industrial waste, MSW, Introduction to Conversion devices, Incinerators, gasifiers, digestors.	**6 Hours**
Module-2	Biomass Pyrolysis: Pyrolysis types, Manufacture, yields and application of charcoal, Manufacture of pyrolytic oils and gases, Biomass Thermo chemical conversion, Direct combustion.	**6 Hours**
Module-3	Biomass Gasification: Fixed bed system, Downdraft and updraft gasifiers, Fluidized bed gasifiers, Gasifier Design, construction and operation, Gasifier burner arrangement for thermal heating, Gasifier engine arrangement, Equilibrium and kinetic consideration in gasifier operation.	**9 Hours**
Module-4	Biomass Combustion: Biomass stoves, Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation of all the above biomass combustors.	**7 Hours**
Module-5	Biogas: Properties of biogas (Calorific value and composition), Biogas plant technology and status, Bio energy systems, Design and constructional features, Biomass resources and their classification, biochemical conversion, anaerobic digestion, Types of biogas Plants, Applications.	**8 Hours**
Module-6	Bioenergy & Biofuels: Alcohol production from biomass (ethanol), Bio diesel production, Urban waste to energy conversion, Biomass energy programme in India; Urban waste to energy conversion.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Desai, ***Non Conventional Energy***, Wiley Eastern Ltd., 2011.
T2. K. C. Khandelwal and S. S. Mahdi, ***Biogas Technology: A Practical Hand Book***, Tata McGraw-Hill, 1989.
T3. P. Shilpkar and D. Shilpkar, ***Handbook Of Biogas Technology***, Agrotech Publishing, 2009.
T4. C. Y. W. Brobby and E. B. Hagan, ***Biomass Conversion and Technology***, Wiley-Blackwell, 1996.
T5. H. S. Mukunda, ***Understanding Clean Energy and Fuels from Biomass***, Wiley, 2011.

Reference Books:

R1. R. P. Overend, T. Milne, and L. Mudge, ***Fundamentals of Thermochemical Biomass Energy***, Springer, 2011.
R2. V. C. Nelson and K. L. Starcher, ***Introduction to Bioenergy (Energy and the Environment)***, 1st Edition, CRC Press, 2016.

Online Resources:

1. https://nptel.ac.in/downloads/112104168/
2. http://www.issp.ac.ru/ebooks/books/open/Composites_and_Their_Properties.pdf
3. https://nptel.ac.in/courses/Webcourse-contents/IIScBANG/Composite%20Materials/pdf/Lecture_Notes/LNm7.pdf
4. https://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/Composite%20Materials/pdf/Teacher_Slides/mod2.pdf

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

CO1	Understand biomass based resources.
CO2	Understand thermo chemical conversion process of biomass.
CO3	Understand the applications of biomass combustion process in energy conversion.
CO4	Study the design, analysis of biochemical conversion process of biomass.
CO5	Study the design of anaerobic energy conversion system for biomass.
CO6	Study the design of biomass energy conversion to biofuels (biodiesel, gasohol).

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
PO3	Use modern tools, professional software platforms, embedded systems for the diversified applications.
PO5	Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies.
PO6	Visualize the larger picture and correlate the domain knowledge with the global industrial problems.
PO7	Understand the impact of power electronics devices in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1		1			2					2	1	
CO2	1		1			2					1	1	
CO3	1		1			2					1	1	1
CO4	1		1		1	2	2			1	2		1
CO5	1		1		1	2	2			1	2	1	1
CO6	1		1		1	2	2			1	1	1	1