College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Electrical Engineering

Curriculum Structure & Detailed Syllabus (UG Program)
Final Year B. Tech.

(Effective from: A.Y. 2021-22)

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Program Educational Objectives (PEOs)

After the completion of the program

I. Student will be employable in the diversified sectors of the industry, government organizations, public sector and research organizations.

II. Student will pursue higher education in electrical engineering or other fields of their interests, at institutes of repute and high ranking.

III. Student will demonstrate effective communication, life long learning ability, integrity, team work, leadership qualities, concern to environment and commitment to safety, health, legal and cultural issues in the fields they choose to pursue.

Program Outcomes (POs):

Engineering Graduate will be able to:

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problem.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science, and engineering sciences.

PO3: Design/Development Solution: Design solution for complex engineering problems and design system component or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, social and environmental conditions.

PO4: Conduct Investigation of Complex Problem: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusion.

PO5: Method, Tool Usage: Create, select and apply appropriately technique, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with understanding the limitation.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to access societal health, safety, legal and cultural and consequent responsibility relevantto the professional engineering practice.

PO7: Environment and Sustainability: Understand the impact of the professional engineering solution in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principle and commitment to professional ethics and responsibilities and norms of the engineering practices.

PO9: Individual and Team Work: Function effectively as an individual, and as the member or leader in diverse team and multidisciplinary setting.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, and being able to comprehend and write effective reports and design documentation and effective presentation and give and receive clear instructions.

PO11: Project management and Finance: Demonstrate knowledge & understanding of the engineering and management principles and apply these to ones work, as the member and the leader in a team to manage projects and in multidisciplinary environment.

PO12: Life Long Learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in broadest context of technological change.

Program Specific Outcome for Undergraduate (PSOs):

PSO1: To design and develop power electronics hardware and its control to cater the needs of industry Such as electric vehicles, renewable interconnections, smart grid and micro-grid.

PSO2: To analyse and solve the problems related to smart grid using modern techniques and tools.

PSO3: To design, simulate, and make prototype of special purpose machines for enhancing the Performance.

Correlation between the PEOs and the POs

PO/PSO → PEO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H
II	H	H	H	H	H	M	M	H	M	M	M	H	M	M	M
III	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H

List of Abbreviations

Sr. No.	Abbreviation	Stands for:
1	BSC	Basic Science Course
2	SBC	Skill Based Course
3	IFC	Interdepartmental Foundation Course
4	PCC	Program Core Course
5	LC	Laboratory Course
6	HSMC	Humanities Science and Management Courses
7	MLC	Mandatory Learning Course
8	LLC	Liberal Learning Course
9	IOC	Interdisciplinary Open Course

CURRICULUM STRUCTURE OF Final Year B. TECH. (Electrical Engineering)
(Effective from A. Y. 2021-2022)

STRUCTURE FOR UG PROGRAM IN ELECTRICAL ENGINEERING

Semester VII [ELECTRICAL] Scheme A Group E

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	LLC	Liberal Learning Course	1	0	0	1
2.	IOC	Interdisciplinary Open Course	2	0	0	2
3.	MLC	Intellectual Property Right	1	0	0	0
4	DEC	Department Elective-II	3	0	0	3
5	PCC1	Power System Protection	2	0	0	2
6	PCC2	Electric Drives	2	1	0	3
7	PCC3	Control System Design	3	0	0	3
8	LC1	High Voltage Engg. Lab	2	0	2	3
9	LC2	Power System Protection Lab	0	0	2	1
10	LC3	Electric Drives and Control System Lab	0	0	2	1
			16	1	06	19
		Total Academic Engagement and Credits	**23**			**19**

IOC to be offered:

Semester VIII [ELECTRICAL] Scheme A Group E

[For the students who prefer the regular track]

Sr. No.	Course type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	DEC	Department Elective-III	3	0	0	3
2	DEC	Department Elective-IV	3	0	0	3
3	SBC	Major Project Stage-II	0	0	12	8
		Total Academic Engagement and Credits	**19**			**14**

STRUCTURE FOR UG PROGRAM IN ELECTRICAL ENGINEERING

Semester VII [ELECTRICAL] Scheme B Group E

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	MLC	Intellectual Property Right	1	0	0	0
2.	LLC	Liberal Learning Course	1	0	0	1
3.	IOC	Interdisciplinary Open Course	2	0	0	2
5.	DEC	Department Elective II	3	0	0	3
5	PCC1	Power System Protection	2	0	0	2
6	PCC2	Electric Drives	2	1	0	3
7	PCC3	Control System Design	3	0	0	3
8	LC1	High Voltage Engineering Lab	2	0	2	3
9	LC2	Power System Protection Lab	0	0	2	1
10	LC3	Electric Drives and Control Laboratory	0	0	2	1
			16	1	06	19
		Total Academic Engagement and Credits	**23**			**19**

IOC to be offered

Semester VIII [ELECTRICAL] Scheme B Group E

[For the students who prefer the regular track]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	SBC	Internship and Major Project with industry/corporate/ academia	0	0	20	08
2	SLC	Massive Open Online Course II	3	0	0	3
3	SLC	Massive Open Online Course II	3	0	0	3
			6	0	20	14
		Total Academic Engagement and Credits	**26**			**14**

Departmental Electives

ELECTIVE II					
	COURSE TITLE	L	T	P	Credits
1	Electrical Machine Design	3	0	0	3
2	Power Quality: Issues and Mitigation	3	0	0	3
3	Computer Algorithms	3	0	0	3
4	Advanced Machine learning: Deep Learning	3	0	0	3
5	Robotics	3	0	0	3
6	Any PG course/ New Course suggested by DUPC	3	0	0	3

ELECTIVE III					
	COURSE TITLE	L	T	P	Credits
1	Hybrid Electric Vehicles	3	0	0	3
2	Energy Conservation & Audit	3	0	0	3

3	Condition Monitoring of Power System Apparatus	3	0	0	3
4	Wind and Solar Power	3	0	0	3
5	Advanced Data Structures	3	0	0	3
6	Internet of Things	3	0	0	3
7	Auto SAR (Industry Supported)	3	0	0	3
8	Any PG Course/ New Course suggested By DUPC	3	0	0	3

ELECTIVE IV					
	COURSETITLE	L	T	P	Credits
1	Smart Grid Technologies	3	0	0	3
2	HVDC and FACTs	3	0	0	3
3	Energy Storage Systems	3	0	0	3
4	EHVAC	3	0	0	3
5	Industrial Automation and Control	3	0	0	3
6	Any PG Course/ New Course suggested By DUPC	3	0	0	3
7	Big Data Analysis	3	0	0	3

MINOR COURSES

S. No.	Semester	Electrical Minor	Renewable Minor	Lectures	Credits
1	V	Electrical Machines and Drives	Solar Energy Systems	3	3
2	VI	Electrical Power System	Wind Energy Systems	3	3
3	VII	Utilization of Electrical Energy	Bio energy Systems	3	3
4	VIII	Energy Conservation and Audit	Hydro Energy Systems	3	3

Semester-VII

(MLC) Intellectual Property Rights

Teaching Scheme	Examination Scheme
Lectures:1hrs/week	End-Sem Exam-50

Course Outcomes:

1. Understood the importance of IPR.
2. Understood how IPR are regarded as a source of national wealth and mark of an economic leadership in the context of the global market scenario.

Course Objectives:

1. To understand the need of awareness and knowledge about IPR.
2. To understand how PR contributes to the economic development of the society and in turn the nation.
3. To understand that IP is a law, economics, technology and business.
4. Understand how IPR protection provides an incentive to inventors for further research work and investment in R &D.

Syllabus Contents:

Unit 1 **[2 Hrs]**
Introduction
Nature of Intellectual Property, Patents, Designs, Trademarks and Copyrights, Process of patenting and Development-technological research, Innovation, patenting, development.

Unit 2 **[2 Hrs]**
International Scenario
International cooperation on Intellectual Property, Procedure for grants of patents, patenting under PCT.

Unit 3 **[3 Hrs]**
Patent Rights
Scope of Patent Rights, Licensing and transfer of technology, Patenting formation and databases, Geographical Indications.

Unit 4 **[3 Hrs]**

New developments in IPR

Administration of Patent system, New developments in IPR, IPR Biological systems, Computers, Software, etc., Traditional knowledge, Case studies, IPR and IIT's objectives towards learning IPR.

Unit 5 **[3 Hrs]**

Trademark and patenting

Registered and unregistered trademarks, designs, concepts, idea patenting.

Textbooks:

1. Hilbert, "Resisting Intellectual Property", Taylor & Francis Ltd. ,2nd ed.2007.

Reference Books:

2. Robert Merges, Peter S. Meneil, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 4th ed., 2007

((DEC II)-1) Electrical Machine Design

Teaching Scheme

Lectures: 3 hrs./week

Examination Scheme:

100 marks: Continuous evaluation

Assignments /Quiz/ Test- 40 Marks,

End - Seem Exam – 60 Marks

Course Outcomes:

By the end of the course, students will be able to

1. Select proper commercial materials, their properties and selection criteria, IS standards used in electrical machine design.
2. Design commercial transformers and induction motors as per specifications.
3. Apply computer-aided optimization techniques for the design of electrical machines
4. Design electrical machines using finite element-based software.

5. Analyze electrical machines using finite element-based software.

Unit 1: Introduction **[6 Hrs]**

Transformers and three phase induction motors - types, specifications, constructional features, conducting, magnetic and insulating materials, heating and cooling in electrical machines, magnetic circuit calculations.

Unit 2: Transformer Design **[7 Hrs]**

Magnetic circuit specific electric and magnetic loading selection, output equation, core and yoke sections, main dimensions design, core loss from design data, winding design, calculations of magnetizing current, winding resistances and leakage reactance's, losses, performance, temperature rise, cooling methods, radiators, tank wall dimensions.

Unit 3: Induction Motor Design (Part I) **[6 Hrs]**

Output equation, specific electrical and magnetic loading, main dimensions, selection of slots, stator design, stator slots, turns per phase, selection of air gap, unbalanced magnetic pull estimation, harmonic minimization, squirrel cage and wound rotor design.

Unit 4: Induction Motor Design (Part II) **[7 Hrs]**

Calculation of magnetic circuit, MMF calculations, stator teeth, stator core, effect of saturation, magnetizing current, no load current and its core loss component, leakage fluxes and reactance calculations, performance calculations - losses, efficiency, temperature rise, maximum torque from circle diagram.

Unit 5: Computer Aided Design (CAD) of Electrical Machines **[6 Hrs]**

Limitations and assumptions in traditional designs, need of CAD, analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation.

Unit 6: Electrical Machine Design using FEA Software packages **[8 Hrs]**

Introduction to complex structures of modern machines- PMSMs, BLDCs, SRM, LSPMSMs Claw pole machines etc., need of commercial FEA based software, analytical design modules, 2D and 3D machine models, analyzing steady state and transient performance of the designs.

Textbooks:

1. A. K. Sawhney – "A Course in Electrical Machine Design", 10th Edition, - Dhanpat Rai and sons New Delhi, 2013.

2. M. G. Say –The Performance and Design of A.C. Machines, 3rd Edition, CBS Publishers and distributors, Delhi, Reprint 2002.

3. S. K. Sen, "Principles of Electrical Machine Design with computer programs", Oxford and IBH Company Pvt. Ltd. New Delhi, 2006.

Reference Books:

1. A. Shanmugasundaram, G. Gangadharan, R. Palani, -Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint, John Wiley Eastern Ltd., New Delhi, 1988.

2. K. M. Vishnu Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications, 2008.

3. Electrical machines and equipment design exercise examples/ Tutorials using Ansoft's Maxwell 2D machine design package.

((DEC II)-2) Power Quality: Issues and Mitigation

Teaching Scheme:
Lectures: 3hr/week

Examination Scheme:
100 Marks: Continuous evaluation
Assignments/Quiz-40Marks,
End Sem. Exam: 60 Marks

Course Outcomes:

Upon successful completion of this course, students will be able to

1. Learn to distinguish between the various categories of power quality problems.
2. Understand the root of the power quality problems in industry and the impact on performance and economics.
3. Learn to apply appropriate solution techniques for power quality mitigation based on the type of problem.
4. Introduce the importance of grounding on power quality.
5. Introduce power distribution protection techniques and its impact on voltage quality

Unit 1:Electric Power Quality **[8 hrs]**

Definition; Power Quality evaluation procedures; Terms and definitions: transients ,long duration voltage variations, short-duration voltage variations, voltage imbalance, wave form distortion, voltage fluctuation; sources of sags and interruptions, solutions at the end user level.

Unit 2: Transient Over voltages **[6 hrs]**

Sources of transient over voltages devises for overvoltage protection, switching transient problems with loads, computer tools for transient analysis.

Unit 3: Fundamental soft Harmonics **[8 hrs]**

Harmonic distortion, power system quantities under non sinusoidal conditions, harmonic indices harmonic sources from industrial loads, effects of harmonic distortion, devices for controlling harmonic distortion, standards on harmonics.

Unit 4: Power Quality Monitoring **[7 hrs]**

Monitoring considerations, historical perspective of power quality measuring instruments, power quality measurement equipment, application of intelligent systems, power Quality Monitoring standards.

Unit 5: Modeling of Networks and components under non sinusoidal conditions **[6hrs]**

Transmission and distribution systems, resonance, shunt capacitors, transformers, electric machines, ground systems.

Unit 6: State Estimation applied to Power Quality Assessment **[6 hrs]**

State estimation, least square state estimators, Kalman filters, Artificial Neural Networks.

Textbooks

1. Roger C. Dugan, "Electrical Power Systems Quality", McGraw-Hill Publication, 3/e
2. G.T. Heydt, "Electric Power Quality", Starsina Circle Publications, 2/e

Reference Book

1. J. Arrillaga ,N.R .Watson, "Power System Quality Assessment", John Willey & Sons, 3/e.

((DEC II)-3) Computer Algorithms

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2 – 20 Marks each
End-Sem Exam – 60 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. State the need of analyzing algorithms and basic techniques used in the analysis
2. Interpretation of complexity theory and standard design techniques
3. Use standard techniques to solve problems from different domains and go for approximate solutions when the problems are computationally difficult

Unit 1 : Introduction **[6 Hrs]**

Objectives of time and space analysis of algorithms; Order notations (O, Θ, Ω notations) with reference to the following algorithms: bubble sort, selection sort, insertion sort, Recurrences.

Unit 2 Data Structures **[6 Hrs]**

Arrays, Linked lists, Stacks and Queues. Binary search trees, Red-Black trees, Hash tables, Basics of graphs and their representations, Heaps and Heapsort

Unit 3: Design Techniques **[6 Hrs]**

Divide and Conquer-Merge sort, Greedy Algorithms-knapsack problem, Backtracking-8- Queens problem

Unit 4: Selected Algorithms from various areas **[7 Hrs]**

Graph Theory: Elementary Algorithms, DFS, BFS, Topological Sort, Minimum spanning trees 36 (Kruskal and Prim's algorithms), Shortest Paths: Single Source shortest paths – Bellman-Ford algorithm, Dijkastra’s algorithm, String Matching: The naïve string-matching algorithm, The Robin-Karp algorithm, The Knuth-Morris-Pratt algorithm, Geometric algorithms**.**

Unit 5: Introduction to Advanced Algorithm Design Techniques **[5 Hrs]**

Amortized Analysis: Aggregate analysis, The accounting method, The potential method, Probabilistic Analysis and Randomized Algorithms, The hiring problem, Indicator random variables, and Approximation Algorithms.

Unit 6 : Complexity Theory **[6 Hrs]**

Lower-bound arguments, NP-completeness, Introduction to NP-Complete

Text Books:

1. Thomas Cormen, Charles Leiserson, Ronald Rivest and Cliford Stein, "Introduction to• Algorithms", PHI

Reference Books:

2. E. Horowitz and S. Sahni. "Fundamentals of Computer Algorithms" , Galgotia, 1991
3. V. Aho, J. E. Hopcroft, and J. D. Ullman, "The Design and Analysis of Computer Algorithms",Addison Wesley, 1974

((DEC II)-4) Advanced Machine learning: Deep Learning

.

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Upon successful completion of this course the students will be able to,

1. understand complexity of Deep Learning algorithms and their limitations.
2. understand neural networks and data more precisely.
3. apply common Deep Learning algorithms in practice.
4. perform experiments in Deep Learning using real-world data.

Unit 1 **[8 Hrs]**

Introduction

Introduction to deep learning, Neural Network, Feed-forward Neural networks, Gradient descent and the back propagation algorithm, Unit saturation, aka the vanishing gradient problem, and ways to mitigate it. Relu Heuristics for avoiding bad local minima, Heuristics for faster training, Regularization, Dropout.

Unit 2 **[6 Hrs]**

Convolutional Neural Networks
Introduction to CNNs, Kernel filter, Principles behind CNNs, Multiple Filters,CNN applications.

Unit 3 **[6 Hrs]**

Recurrent Neural Networks
Introduction to RNNs, Unfolded RNNs, LSTM, GRU, Encoder Decoder architectures, RNN applications.

Unit 4 **[8 Hrs]**

Representation Learning
Unsupervised pre-training, transfer learning, domain adaptation, distributed representation, discovering underlying causes, Neural architecture search, network compression, graph neural networks.

Unit 5 **[8 Hrs]**

Deep Unsupervised Learning
Auto encoders (standard, sparse, de-noising, contractive, etc), Variational Auto-encoders, Adversarial Generative Networks.

Unit 6 **[6 Hrs]**

Deep Learning Applications
Image Processing, Natural Language Processing, Speech Recognition, Video Analytics.

Text Books:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2016.
2. Aston Zhang and Zachary C. Lipton and Mu Li and Alexander J. Smola, “Dive into Deep Learning”, 2019

Reference Books:

1. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
2. Hastie, Tibshirani, Friedman, “The elements of Statistical Learning”, Springer Verlag.

((DEC II)-5) Robotics

Teaching Scheme:

Lectures: 3 Hrs./week

Examination Scheme:

T1 and T2: 10 Marks each

End-Sem Exam: 50 Marks

Assignments : 15 Marks

Project: 15 Marks

Course Outcomes:

After the completion of this course, the students will be able to:

1. Perform kinematic and dynamic analyses with simulation.
2. Design control laws for a simple robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given industrial application.

Unit 1: Introduction

History of robots, Classification of robots, Present status and future trends. Basic components of robotic system. Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom. Mechanisms and transmission, End effectors, Grippers-different methods of gripping, Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, Cam type gripper, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot.

UNIT 2: Drive systems and Sensors

Drive system- hydraulic, pneumatic and electric systems Sensors in robot – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors.

UNIT 3: Kinematics and Dynamics of Robots

2D, 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple transformation, Simple problems. Matrix representation, Forward and Reverse Kinematics Of Three

Degree of Freedom, Homogeneous Transformations, Inverse kinematics of Robot, Robot Arm dynamics, D-H representation of robots, Basics of Trajectory Planning.

UNIT 4: Robot Control, Programming and Applications

Robot controls-Point to point control, Continuous path control, Intelligent robot, Control system for robot joint, Control actions, Feedback devices, Encoder, Resolver, LVDT Motion Interpolations, Adaptive control. Introduction to Robotic Programming, On-line and off-line programming, programming examples. Robot applications-Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting.

Text Books:

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999.

Reference Books:

1. S.R. Deb, "Robotics Technology and flexible automation", Tata McGraw-Hill Education., 2009.
2. Richard D. Klafter, Thomas.A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.
3. Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.
4. P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.
5. Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.
6. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987
7. Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985

(PCC 1) POWER SYSTEM PROTECTION

Teaching Scheme:

Lectures:2 hrs/week

Examination Scheme:

Continuous Evaluation

Quiz/Assignments– 40 marks

End-SemExam-60 Marks

Course Outcomes:

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

1. Understand working of different types of circuit breakers and L.T. switchgear and select for particular application.
2. Select the different components of protection system such as CT, PT, relays etc.
3. Design protection of transformer, generator, transmission lines, bus bar, motors etc.
4. Estimate the phasors using different algorithms and design the numerical protection system.

Unit 1 **[06 hrs]**

Circuit Breakers

Circuit Breakers: arc voltage, arc interruption, resistance switching, interruption of capacitive and inductive current, circuit breaker ratings, classification of C.Bs- air break, air blast, vacuum, minimum oil and bulk oil CB, SF_6 C.B. L.T. switchgear:-MCB, MCCB, HRC fuse-construction and application, Circuit breaker selection.

Unit 2 **[07 hrs]**

Numerical Protection

Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays. Fundamentals of PMU and WAMS.

Unit 3 **[08hrs]**

Fundamentals of Power System Protection and Over Current Protection

Need of protection, protection principles, protection paradigms-apparatus protection and system protection, desirable attributes of protection. Introduction to C.T., equivalent circuit, C.T. saturation and offset current, V.T. equivalent circuit, Ferro-resonance, Review of calculation of fault currents, fuse protection, over current protection, PSM and TMS setting, phase relay coordination, earth fault protection using over current relays, introduction to directional over-current relays.

Unit 4 **[06 hrs]**

Transmission System Protection

Introduction to distance relaying, zones of protection, effect of fault arc resistance, directional properties, setting and coordination of distance relays, pilot protection with distance relays ,realization of distance relays using numerical relaying algorithms, Basics of load encroachment and power swing.

Unit 5 **[07 hrs]**

Protection of Transformer, Generator, Motors

Percentage differential protection, magnetic inrush current phenomenon, percentage differential relay with harmonic restraint, restricted earth fault protection, incipient faults, Buchholz relay, protection against over fluxing. Generator protection: Stator phase and ground fault protection, protection against unbalanced loading ,loss of excitation, loss of prime mover and over speeding, protection of large motors.

Unit 6 **[06 hrs]**

Bus bar protection, Lightning Protection

Bus bar protection: Different bus bar arrangements, differential protection of bus bar, high impedance differential relay. Lightning and switching over voltages, need and types of lightening arresters, insulation coordination.

Text Books:

1. A Web Course on Digital protection of power system by Prof. Dr. S. A. Soman, IIT Bombay.
2. Fundamentals of power system protection by Y.G. Paithankar, S.R. Bhide., Prentice Hall, India, second edition, 2010.

Reference Books:

1. Computer relaying for power systems by A.G.Phadke, J.S.Thorp-research studies press ltd. England John Wiley & sons Inc. New York.
2. Protection of power systems by Blackburn.

(PCC 2) Electric Drives

Teaching Scheme:
Lectures : 2 hrs/week
Tutorial : 1hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz/ Test- 40 Marks,
End - Seem Exam – 60 Marks

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

1. Configure the basic drive system combination as per application
2. Analyse the motor drive system for various industrial loads
3. Select and estimate motor rating as per duty of operation
4. Design dc motor control circuitry and select devices for speed and torque
5. Design induction motor control circuitry and select devices for speed and torque
6. Design dc motor control circuitry and select devices for speed and torque
7. Analyse the motor situation during starting and braking.

Syllabus Contents:

Unit 1:
Basics of Electric Drives and Control **[6 Hrs]**
Definition, advantages of electrical drives, components of electric drive system, selection factors, types and status of electrical drives, speed control, drive classifications, close loop control of drives, phase locked loop (PLL) control.

Unit 2:
Dynamics of Electrical Drives **[6 Hrs]**
Motor-Load Dynamics, speed torque conventions and multi quadrant operation, equivalent values of drive parameters. load torque components, nature and classification of load torques, constant torque and constant power operation, steady state stability, load equalization.

Unit 3: **[4 Hrs]**
Selection of Motor Power Rating

Thermal model of motor for heating and cooling, classes of motor duty, determination of motor ratings for various operation duty cycle.

Unit 4: DC Motor Drives **[4 Hrs]**

DC motors and their performance starting, transient analysis, speed control, Ward-Leonard drives, controlled rectifier fed drives, full controlled 3-phase rectifier control of dc separately excited motor, multi quadrant operation, Chopper controlled drives, closed loop speed control of DC motor, starting and braking of dc motors

Unit 5: Induction Motor Drives **[6 Hrs]**

Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, slip power recovery – Static Kramer and Scherbius drive, single phase induction motor starting, braking and speed control, introduction of vector control, industrial applications.

Unit 6: Synchronous Motor and Brushless DC Motor Drives **[4 Hrs]**

Synchronous motor types, operation with fixed frequency, variable speed drives, vector control, PMAC and BLDC motor drives, Stepper motor drives, switch reluctance motor drives, industrial applications.

Text Books:

1. G. K. Dubey, Fundamentals of Electrical Drives, Second edition (sixth reprint), Narosa Publishing house, 2001

Reference Books:

1. M. H. Rashid, ―Power Electronics -Circuits, devices and Applications‖, 3rdEdition, PHI Pub. 2004.
2. B. K. Bose, ―Modern Power Electronics and AC Drives‖, Pearson Education, Asia, 2003.

(PCC 3) Control System Design

Teaching Scheme:
Lectures:3hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignments/Quiz-40 Marks,
End-Seem Exam – 60Marks

Course Outcomes:

By the end of the course, students will be able to

1. Define the specifications of linear control systems using transfer function models, state-space models, and discrete-time models.
2. Perform the linear control system designs in time and frequency domain
3. Use graphical tools like Bode plots, Root locus plots.

Syllabus contents:

Unit 1 **[8 Hrs]**
Linear Control Methods
Introduction to process control, PID control and design methods, tuning, Implementation of PID Controllers, Special Control Structures-Feedforward and ratio control, Predictive control, Cascade control

Unit 2 **[7 Hrs]**
Control System Design in time domain
Time and frequency domain design specifications and their correlation, Use of Cascade compensation to improve systems performance, Lead, Lag and Lag-lead compensators and the role in improvement of system behavior, Design of Lead, Lag and Lag-lead in time domain using root locus.

Unit 3 **[7 Hrs]**

Control System Design in Frequency Domain

Lead compensator, Lag compensator, their design in frequency domain using Bode plots, and Lag-Lead compensator design in frequency domain.

Unit 4 **[7 Hrs]**

State Space Analysis of Continuous System

Review of state variable are presentation of continuous system, conversion of state variable models to transfer function and vice-versa, solution of state equations and state transition matrix, controllability and observability, design of state feedback controller and observer.

Unit 5 **[6 Hrs]**

Discrete System

Discrete system and discrete time signals, state variable model and transfer function model of discrete system, conversion of state variable model to transfer function model and vice-versa, modeling of sample hold circuit,

Unit 6 **[6 Hrs]**

Analysis of Discrete Systems:

Solution of state difference equations, steady state accuracy, Stability of discrete system synthesis -plane and Jury stability criterion, bilinear transformation.

Text/Reference Books:

1. Digital Control and State variable Methods", Tata Mc Graw Hill Ajit K. Madal, "Introduction to Control Engineering: Modeling, Analysis and Design "New Age International.
2. S. Mukhopadhyay, S. Sen, A.K. Dev, "Industrial Instrumentation, Control and Automation", Jaico Publication House.
3. B.C. Kuo, "Digital Control Systems" Sounders College Publishing
4. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International. M. Gopal,"

(LC 1) High Voltage Engineering Lab

Teaching Scheme:
Theory :2hrs/week

Examination Scheme:
100 marks: Continuous evaluation

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Select proper insulating medium suitable for high voltage systems
2. Generate a high DC, AC voltage and currents in lab
3. Measure the high voltages and currents.
4. Design the high voltage laboratory and plan equipment installations in it
5. Test gases, liquid and solid materials in the high voltage laboratory
6. Refer various standards to carry out HV tests on various equipments

List of Experiments:

1. To study the use of Sphere gap as a Voltmeter for measurement of High Voltages
2. To measure the Dielectric strength of air
3. To study the breakdown under Uniform and non-uniform fields
4. To measure the breakdown strength of Liquid dielectrics as per I. S.
5. To study the effect of gap-length on B. D. strength of Liquid dielectrics
6. To measure the breakdown strength of various solid dielectrics
7. To study the breakdown of Composite dielectrics
8. To perform High voltage withstand test on Cables/ Safety gloves/ Safety shoes etc.
9. To study the flashover phenomenon
10. To simulate Corona discharge
11. To study Horn-gap surge diverter
12. To study Impulse generator
13. Visit to Substation / Special purpose high voltage laboratory (Minimum ten experiments out of the above-mentioned list to be performed)

(LC 2) POWER SYSTEM PROTECTION LAB

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme
Term Work: 50 Marks
Oral/Practical: 50 Marks

Course Outcomes:

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

1. Set and carry out tests on different relays such as differential relay, overcurrent relay, distance relay, over/under voltage relay etc. and analyze the test results.
2. Simulate and analyze the symmetrical and unsymmetrical faults, Implement phasor estimation and relay coordination algorithms.
3. Perform simulation and modelling of protection system using MATLAB/PSCAD/ATP.

The laboratory consists of minimum eight experiments from following list and any other experiment based on the prescribed syllabus.

1. To test over current protection relay and plot its characteristics.

2. To test under and over frequency relay.
3. To test under and over voltage relay.
4. Transformer protection using differential relay for in zone trip faults.
5. To perform the pick-up test for differential relay.
6. To test differential relay and plot percentage biased characteristics.
7. To understand the working of percentage biased differential relay for transformer protection.
8. To understand the working of distance relay.
9. To compute fault current level /MVA for a symmetrical fault and verify it by simulation.
10. To compute fault current level /MVA for unsymmetrical faults and verify it by Simulation.
11. To estimate phasor from given signal using two sample and three sample method.
12. To estimate phasor from given signal using full cycle and half cycle Fourier algorithm.

(LC 3) ELECTRICAL DRIVES AND CONTROL LABORATORY

Teaching Scheme:

Practical: 2 hr/week

Examination Scheme:

Term Work: 50 Marks

Oral/Practical: 50 Marks

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To understand the basics of electric drives and fundamentals of drive dynamics
2. To learn and analyze DC drive
3. To learn and analyze different steady state speed control methods for Induction motors, and understand the closed loop block diagrams for different methods.
4. To get introduced to modern synchronous motors and drives.
5. To apply control system theory and engineering laboratory fundamentals to model and characterize dynamic systems and synthesize single-input/single-output control systems using classical control methods.

6. To design and implement control systems for several mechanical systems.

Following experiments and MATLAB based assignments are to be carried out by the students:-

1. PID control design and verification for temperature control system.
2. Controller Design(Root Locus and Bode plots)using SISO tool in MATLAB.
3. Position Control of DC Motor.
4. Pole Placement by State Feedback in MATLAB.
5. Discretization and study of a practical system with understanding of effect of sampling time on stability.
6. Modeling of separately excited DC Motor (system identification / parametric measurement).
7. Armature control of S.E.DC Motor - Constant Torque, Constant HP.
8. Chopper fed two quadrant DC drive
9. Half controlled rectifier fed DC drive
10. Fully fed controlled rectifier fed DC drive
11. Four quadrant DC Drive - Motoring and Braking
12. T-N characteristics using voltage control
13. T-N characteristics using V/F control
14. T-N characteristics of different loads
15. Simulation of closed loop DC drive
16. Simulation of closed loop V/F drive
17. Study of commercial AC and DC drives.
18. Microcontroller based chopper fed DC drive

SEMESTER VIII

DEPARTMENTAL ELECTIVE III

((DEC-III) -1) Hybrid Electric Vehicles

Teaching Scheme

Lectures:3hrs/week

Tutorial:----

Examination Scheme

100marks: Continuous evaluation-

Assignments/Quiz-40Marks,

End-Seem Exam – 60Marks

Course Outcomes:

At the end of this course students will understand:

1. Concept of Electric Vehicles, Hybrid Electric Vehicles & Plugin Hybrid Electric Vehicles
2. Power electronics & electric machine requirements of EVs &HEVs
3. Design issues of EVs &HEVs
4. How to model EVs &HEVs

Syllabus Contents:

Unit1 **[07hrs]**

Introduction to EVs &HEVs:

A brief history of EV & PHV, Basics of EV&HEV, Architectures of EV&HEV, HEV fundamentals.

Unit2 **[07hrs]**

Plug-in HEVs:

Introduction to PHEVs, PHEV architectures, Power management of PHEVs, Fuel economy of PHEVs, PHEV design & component sizing, Vehicle-to-grid technology.

Unit3 **[04hrs]**

Power Electronics in EVs &HEVs:

Introduction, Principles of power electronics, Rectifiers, Converters, Inverters, Battery chargers used in EVs & HEVs, Emerging power electronic devices

Unit4 **[06hrs]**

Electric Machines & Drives in EVs & HEVs:

Introduction, Induction motor drives, Permanent magnet motor drives, Brushed & Brushless DC motor, Switched reluctance motors

Unit5 **[06hrs]**

Components & design considerations of EVs &HEVs:

Batteries, Ultracapacitors, Fuel Cells, Controls, Aerodynamic considerations Consideration of rolling resistance Transmission efficiency, Consideration of vehicle mass, Electric vehicle chassis & body design, General issues in design

Unit6 **[06hrs]**

Modelling, Simulation & case studies of EVs & HEVs:

Introduction, Fundamentals of vehicle system modeling, HEV modeling using ADVISOR & PSAT, Case Studies-Rechargeable battery vehicles, Hybrid vehicles

Text Books:

1. Chris Mi, M. Abul Masrur, David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.

Reference Books:

1. Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", 2009 ,CRC Press.
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2003, Wiley publication.

((DEC III)-2) Energy Conservation and Audit

Teaching Scheme

Lectures:3hrs/week

Examination Scheme

100 marks: Continuous evaluation-

Assignments/Quiz-40Marks,

End-Seem Exam – 60Marks

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Identify, formulate and solve energy related problems in the broad areas like electrical and mechanical installations, electrical machines, power systems.
2. Plan and execute energy management strategies.
3. Perform energy audit and put forward practical solutions for energy conservation.
4. Understand the energy billing and financial aspect in energy audit.

Syllabus contents:

Unit 1

Energy Scenario **[5 Hrs]**

Energy sources-Primary and Secondary, Commercial and Non-commercial, Energy scenario in India and Global scenario, Energy Security, Energy and GDP, Energy Intensity, Energy conservation and its importance, Energy Conservation Act 2001 and related policies, Role of Non- conventional and renewable energy.

Unit 2:

Energy Management and Integrated Resource Planning **[6 Hrs]**

Definition and Objectives of Energy management, Energy management strategy, Key elements, Responsibilities and duties of Energy Manager, Energy efficiency Programs, Energy Monitoring System, Importance of SCADA, Analysis techniques, Cumulative sum of differences (CUSUM)

Unit 3

Energy Audit **[6 Hrs]**

Definition, need of energy Audit, Types of Energy Audit, Maximizing system efficiency, Optimizing the input energy requirements, fuel and energy substitution, Energy Audit instruments and metering, thermography, SMART metering

Unit 4

Financial Analysis and Management **[7 Hrs]**

Investment need, Financial analysis techniques, Calculation of Simple Pay-back period, return on investment, cash flows, risk and sensitivity analysis, Time value of money, Net Present value, Breakeven analysis, Cost optimization, Cost and Price of Energy services, Cost of Energy generated through Distributed Generation

Unit 5

Energy Efficiency in Electrical Utilities **[7 Hrs]**

Electrical billing, power factor management, distribution and transformer losses, losses due to unbalance and due to harmonics, Demand Side Management, Demand-Response, Role of tariff in DSM and in Energy management, TOU/TOD tariff, Power factor tariff, Integrated Resource Planning and Energy Management Energy conservation in Lighting systems, HVAC, Electric Motors, Pump and Pumping systems

Unit 6

Energy Efficiency in Thermal Systems **[6 Hrs]**

Fuels and combustion, properties of Fuel Oil, coal and gas, storage and handling of fuels, principles of combustion, combustion of oil, coal, gas. Energy efficiency in Boilers, Steam systems, Furnaces, Insulation and Refractors.

Text Books:

1. Guidebooks for National Certification Examination for Energy Manager/Energy Auditors Book General Aspects (available online)

2. Guidebooks for National Certification Examination for Energy Manager/Energy Auditors Book-2,Thermal Utilities (available online)

3. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)

4. Guide books for National Certification Examination for Energy Manager Energy Auditors Book-4,(available online).

Reference Books:

1. S.C. Tripathy, "Utilization of Electrical Energy", Tata McGraw Hill
2. Success stories of Energy Conservation by BEE, New Delhi(www.bee-india.org)

((DEC III)-3) Condition Monitoring of Power System Apparatus

Teaching Scheme:

Lectures:3hrs/week

Tutorial:-------

Examination Scheme:

100marks: Continuous evaluation-

Assignments/Quiz/ Test-40 Marks,

End-Seem Exam – 60Marks

Course Outcomes:

By the end of the course, students will be able to

1. Understand the necessity of condition monitoring and reliability.
2. Have knowledge about the conventional and modern methodologies/techniques.
3. Develop basic functional models for condition monitoring system to different kind of power apparatus.
4. Determine life expectancy of the equipment

Syllabus contents:

Unit1

Basic Considerations and Maintenance

Basic definitions, terminologies, symbolic representation, Necessity from technical social, financial aspect, types off faults in electrical equipment {Electrical equipment such as transformer, CT/PT and rotating electrical machines, CBs, etc.}, maintenance strategies, breakdown maintenance, planned, preventative and condition based maintenance

Unit2

Testing of Electrical Equipment's

Cables, Transformers, Induction motor, Capacitor banks, conventional methods, Measurement of insulation resistance, Diagnostic Testing: Routine tests, type tests, special tests, offline tests, Causes of failure and remedies.

Unit3

Analysis tools

Frequency Response Analysis (SFRA), Partial Discharge (PD), Time Domain Dielectric Response (TDDR), Frequency Domain Spectroscopy (FDS), Chemical analysis. Image processing techniques.

Unit4 **[0**

Online condition monitoring and instrumentation

Recent methods (online), vibration, chemical and temperature monitoring, sensor and data acquisition system, Modern algorithms, GA, and signal processing techniques. Application to various equipment's such as transformer, induction motor, synchronous generator and motor, DC motor, CT and PT, case studies.

Unit5 **[0**

Current, Flux and Power Analysis

Discrete time Fourier series and its convergence, discrete time Fourier Transform, its properties, frequency response. Introduction to DFT in time domain and frequency domain, Derivation of DFT from DTFT, Inverse DFT, Convolution using DFT, Computational Complexity of the DFT, Decimation-in-time FFT Algorithm, Decimation In Frequency FFT Algorithm, Wave let transform, Lab view platform

Unit6 **[0**

Reliability and failure e rate Assessment

Comparison of DITANDDIF algorithms. Introduction to FIR and IIR Filter Design. Calculation of Power Equipment Reliability for Condition-based Maintenance Decision-making, Optimum Reliability- Centered Maintenance, Cost Related Reliability Measures for Power System Equipment, Reliability based replacement refurbishment/planning.

Text Books:

1. P.Vas, "Parameter estimation, condition monitoring and diagnosis of electrical machines", Clarendon Press Oxford, 1993.
2. P.Tavner, Li Ran, J. Penmanand H. Sedding," Condition monitoring of rotating electrical machines", IET press, 2008.

Reference Books:

1. Xose M Lo´pez, Ferna´ndez, H Bu¨ lent Ertan, J Turowski, "Transformers analysis, design, and measurement", CRC Press,2012
2. S.V. Kulkarni and S.A. Khaparde, "Transformer Engineering: Design, Technology and Diagnostics", Second edition, CRC Press,2013
3. R. Billinton and R.N. Allan, "Reliability Evaluation of Power Systems, 2nded.NewYork", NY, USA: Plenum, 1996.
4. Videos on Transformer condition evaluation with ABBs Mature Transformer Management Program
5. Induction motor condition monitoring with ABBs, Siemens, General Electricals (source You Tube)

((DEC III)-4) Advances in Wind and Solar Power Technologies

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2 – 20 Marks each
End-Sem Exam – 60 Marks

<u>Course Outcomes:</u>

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

1. Appreciate the importance of renewable energy sources.
2. Demonstrate the knowledge of the generation aspects of wind and solar power and issues for grid integration.
3. Select suitable power electronics systems for wind and solar applications.
4. Identify and solve the power quality issues in wind and solar grid tied systems.

Unit 1

[08 hrs]

Wind Power Basics
History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power - cumulative distribution functions, site selection and layout of wind farm, Fixed and Variable speed wind turbines, Wind generator topologies.

Unit 2

[06 hrs]

Solar Power basics
Solar cells & panels, performance of solar cell, estimation of power obtaind from solar power, solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems

Unit 3

[06 hrs]

Grid Integration – Wind Power
Wind power integration in electric grid, requirements of grid connected wind power systems, interface issues, operational issues, simulation of grid connected wind power system.

Unit 4

[06 hrs]

Grid Integration – Solar Power
Solar power integration in electric grid, requirements of grid tied solar power system, interface issues, operational issues, simulation of grid connected solar power system.

Unit 5 **[06 hrs]**

Power Electronics in Renewable Energy Systems

PV module, array, DC – DC converters, Maximum Power Point Tracking (MPPT) algorithms, power electronics in wind power plant, Power electronics in Solar power plant.

Unit 6 **[08 hrs]**

Power Quality Issues

Local and system-wide power quality impact of wind and solar power, power quality issues and mitigation techniques.

Text Books:

1. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Willy and sons, 2004, ISBN0-471-28060-7.
2. S.P. Sukhatme, "Solar Energy", Tata McGrew Hill, second edition, 1996, ISBN 0-07-462453-9.
3. Joshua Earnest and Sthuthi Rachel, "Wind Power Technology", PHI, 2019, ISBN-978-93-88028-49-3.

Reference Books:

1. Thomas Ackermann, "Wind Power in Power Systems", John Willy and sons ltd., 2005, ISBN 0-470-85508-8.
2. Siegfried Heier, "Grid integration of wind energy conversion systems" John Willy and sons ltd., 2006.
3. Mullic and G.N.Tiwari, "Renewable Energy Applications", Pearson Publications, 2013.
4. John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", Wiley Inter science Publication, 1991

((DEC III)-5) Advanced Data Structures

Teaching Scheme:

Lectures:3Hrs/week

Examination Scheme:

Assignment/Quizzes – 40 marks

End Sem Exam -60marks

Course Outcomes:

Students will be able to:

1. Apply software development lifecycle in software industry.
2. Identify the importance of software requirements problem to understand the requirement management process.
3. Design and analyse effective use of UML using different design strategies.
4. Devise the procedure to assure the quality and maintain ability of the product before and after deployment.
5. Summarize different testing strategies.

Syllabus contents:

Unit1 **[6 Hrs]**

Review of Basic Concepts:

Abstract data types Data structures, Algorithms, Big Oh, Small Oh, Omega and The notations, Solving recurrence equations, Master theorems, Generating function techniques Constructive induction

Unit2 **[10 Hrs]**

Advanced Search Structures for Dictionary ADT

Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions, Trie; **Hashing:** Simple tabulation hashing; chaining, dynamic perfect hashing, linear probing, cuckoo hashing

Unit3 **[6 Hrs]**

Union Find Related Structures

Union-Find: Merging Classes of a Partition Union-Find with Copies and Dynamic Segment Tree, List Splitting, Problems on Root-Directed Trees, Maintaining a Linear Order

Unit4 **[6 Hrs]**

Data Structures for Partition ADT

Weighted union and path compression, Applications to finite state automata minimization, Code optimization

Unit5 **[4 Hrs]**

Data Structure Transformations

Making Structures Dynamic, Making Structures Persistent

Unit6 **[8 Hrs]**

Computational Geometry

Geometric data structures, Planes we paradigm Convex Hull Different Paradigms and Quick hull, Dual Transformation and Applications, Lower Bounds on Algebraic tree model, Point Location and Triangulation

Textbooks:

1. Introduction to Algorithms; 3rd Edition; by Thomas H. Cormen, Charles E.Leiserson, Ronald L. Rivest and Clifford Stein; Published by PHI Learning Pvt. Ltd.; ISBN-13:978-0262033848 ISBN-10: 0262033844

2. Algorithms 4th Edition by Robert Sedgewick and Kevin Wayne Pearson Education, ISBN-13:978-0321573513
3. Advanced Data Structures, Peter Brass, Cambridge University Press, ISBN-13: 978-0521880374

Reference Books:

1. Algorithms by S. Dasgupta, C.H. Papadimitriou, and U.V. Vazirani Published by Mcgraw-Hill, 2006; ISBN-13: 978-0073523408 ISBN-10: 0073523402
2. Algorithm Design by J. Kleinberg and E. Tardos; Published by Addison-Wesley, 2006; ISBN-13:978-0321295354 ISBN-10: 0321295358
3. Pankaj Jalote, "An Integrated Approach to Software Engineering", Narosa publication house
4. Fred Brooks, "Mythical Manmonths", www.cs.drexel.edu/~yfcai/CS451/.

((DEC III)-6) Internet of Things (IOT)

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Upon successful completion of this course the students will be able to:

1. illustrate the fundamentals of IoT such as paradigms, architectures, possibilities, and challenges.
2. identify suitable hardware and interfaces for IoT deployments.
3. compare IoT protocols for communication.
4. develop cloud computing model and service options.
5. illustrate data analytics and security for IoT.

Unit 1 **[6 Hrs]**

IoT Introduction and Fundamentals

Deciphering the term IoT, Applications where IoT can be deployed, Benefits/Challenges of deploying an IoT, IoT components: Digital Signal Processing, Data transmission, Choice of channel (wired/wireless), back-end data analysis. Understanding packaging and power constraints for IoT implementation.

Unit 2 **[8 Hrs]**

Signals, Sensors, Actuators, Interfaces

Introduction to sensors & transducers, Introduction to electrodes & biosensors, Static and dynamic characteristics of sensors, Different types of sensors, Selection criteria's for sensors / transducers, Commercial IoT sensors / transducers, Signal conditioning modules of IoT system, Energy and power considerations, Introduction to actuators, Different types of actuators, Interfacing challenges, Specification sheets of sensors / transducers, Specifications of actuators, Modules of data acquisition system, Wireless sensor node structure, positioning topologies for IoT infrastructure.

Unit 3 **[8 Hrs]**

Communication and Networking in IoT

Review of Communication Networks, Challenges in Networking of IoT Nodes, range, bandwidth Machine-to-Machine (M2M) and IoT Technology Fundamentals, Medium Access Control (MAC) Protocols for M2M Communications Standards for the IoT, Basics of 5G Cellular Networks and 5G IoT Communications, Low-Power Wide Area networks (LPWAN), Wireless communication for IoT: channel models, power budgets, data rates. Networking and communication aspects: IPv6, 6LoWPAN, COAP, MQTT, Operating Systems need and requirements for IoT.

Unit 4 **[6 Hrs]**

Modern Networking: Cloud computing

Introduction to the cloud computing, History of cloud computing, Cloud service options, Cloud Deployment models, Business concerns in the cloud, Hypervisors, Comparison of Cloud providers, Cloud and Fog Ecosystem for IoT, Review of architecture.

Unit 5 **[6 Hrs]**

IoT Data analytics and Security

OLAP and OLTP, NoSQL databases, Row and column Oriented databases, Introduction to Columnar DBMS C-Store, Run: Length and Bit vector Encoding, IoT Data Analytics. Cryptographic algorithms, Analysis of Light weight Cryptographic solutions IoT security, Key exchange using Elliptical Curve Cryptography, Comparative analysis of Cryptographic Library for IoT.

Unit 6 **[6 Hrs]**

IoT Applications

IoT applications like Home Automation, Precision Agriculture, Smart vehicles, Smart Grid, Industry 5.0.

Text Books:

1. Arshdeep Bahga and Vijay Madisetti, "Internet of Things, a hands on approach", Universities Press (India) Pvt. Ltd., 2017, ISBN: 978-81-7371-954-7.
2. Rajkumar Buyya, Amir Vahid Dastjerdi, "Internet of Things Principles and Paradigms", Elsevier Inc., 2016, ISBN: 978-0-12-805395-9.

Reference Books:

1. William Stallings, "Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud", Addison-Wesley, 2015, ISBN: 9780134175393
2. Samuel Greenguard, "Internet of things", MIT Press.

DEPARTMENTAL ELECTIVE IV

((DEC IV)-1) Smart grid Technologies

Teaching Scheme
Lectures: 3hrs/week
Tutorial : Nil

Examination Scheme
Continuous evaluation- 100 Marks
Assignments/Quiz - 40 Marks,
End-Sem Exam – 60Marks

Course Outcomes:

At the end of this course students will understand:

1. The various aspects of the smart grid, including technologies, components, architectures and applications.
2. The issues and challenges involved.
3. Current initiatives in the development of smart grid at national and international level.
4. The role of communication and information technology in smart grid.

Syllabus contents:

Unit 1 **[5 hrs]**

Introduction to Smart Grid:

Concept, definitions, difference between conventional and smart grid, challenges in smart grid implementation, Overview of the technologies required for the Smart Grid.

Unit 2 **[7 hrs]**

Information and Communication technology:

Communication requirements in smart grid, overview of smart grid standards, Wired and wireless communication, Zigbee, Wireless mesh, Cellular Network Communication, Power line Communication, Digital Subscriber Lines, Wi-Max, Wide Area Network, Neighborhood Area Network, and Home Area Network, information technology, cyber security, standards.

Unit 3 **[6 hrs]**

Smart Transmission System:

Phasor Measurement unit, Phasor data concentrators, Wide are a measurement control and protection, Wide area measurement systems and its applications, Flexible Alternating Current Transmission Systems. High-voltage Direct-current Transmission.

Unit 4 **[6 hrs]**

Smart Substation:

International Electro-technical Communication 61850 standards and benefits, IEC Generic Object Oriented Substation Event -GOOSE, IEC 61850 Substation model Intelligent Electronic Devices integration, Substation LAN, WAN, SCADA, Substation automation.

Unit 5 **[6 hrs]**

Smart Distribution Systems and Energy Storage:

Introduction to Smart Meters, Real-time pricing, Smart appliances, Automatic meter reading (AMR), Demand response, Battery storage, Plug in Hybrid electric vehicles, compressed air, pumped hydro, ultra-capacitors, flywheels, fuel cells.

Unit 6 **[6 hrs]**

Renewable energy integration:

Carbon Footprint, Renewable Resources: Wind and Solar, Micro grid Architecture, Modeling PV And wind systems, Tackling Intermittency, Issues of interconnection, protection &control of microgrid, Islanding.

Text Books:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley, March 2012.
2. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "Smart Grids", Wiley Blackwell, 2012.

Reference Books:

1. Smart Grid: Fundamentals of Design and Analysis (IEEE Press Series on Power Engineering) by James Momoh, Mar20, 2012.
2. Ali Keyhani, Mohammad N.Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley, November2009.
3. Stuart Borlase, "Smart Grids (Power Engineering)", CRC Press, October 2012.
4. Recent literature on Smart Grid.

((DEC IV)-2) HVDC AND FACTS

Teaching Scheme
Lectures:3hrs/week
Tutorial: ----

Examination Scheme
100marks: Continuous evaluation-
Assignments/Quiz-40Marks,
End-Seem Exam – 60Marks

Unit1 **[06hrs]**

Introduction to HVDC:

Introduction of DC Power transmission technology – Comparison of AC and DC transmission, Application and Description of DC transmission system, Planning for HVDC transmission, Modern trends in DC transmission, Types of HVDC Systems.

Unit2 **[07hrs]**

Analysis of HVDC Converters:

Pulse Number-Choice of converter configuration, simplified analysis of Gatez circuit,12-pulse converter based HVDC systems and their characteristics, Control of Converters.

Unit3 **[10hrs]**

Harmonics and Filters:

Introduction–Generation of Harmonics, Design of AC filters and DC filters, HVDC light and HV DC PLUS (Power Universal Link), Series and Parallel operation of converters.

Unit4 **[07hrs]**

Introduction to FACTS:

The concept of flexible AC transmission–reactive power control in electrical power transmission lines, uncompensated transmission line, Introduction to FACTS devices and its importance in transmission Network, Introduction to basic types of FACTS controllers, Comparison of HVDC and FACTS.

Unit5 **[10hrs]**

Shunt and Series Compensation:

Principles of series and shunt compensation, description of static var compensators (SVC), thyristor controlled series compensators (TCSC), static phase shifters (SPS),static synchronous series compensator (SSSC),STATCOM.

Unit6 **[08hrs]**

Hybrid FACTS Controllers:

Unified Power Flow Controller (UPFC)–Principle of operation, modes of operation, applications, IPFC, Modelling and analysis of FACTS Controllers.

Text Books:

1. K.R. Padiyar, "HVDC Power Transmission System", Wiley Eastern Limited, New Delhi, First Edition 1990.
2. T.J.E. Miller, "Reactive Power Control in Electrical System", John Wiley and Sons, New York, 1982.
3. N.G. Hingorani, "Understanding FACTS: Concepts and Technology of FACTS Systems", IEEE Press, 2000.
4. K.R. Padiyar "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
5. A.T. John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE) 1999.

References

1. Colin Adamson and N.G. Hingorani ," High Voltage Direct Current Power Transmission", Garraay Limited, London 1960.
2. J. Wilson Kimbark," Direct Current Transmission", Vol.1 Wiley Interscience, New York, London Sydney 1971.
3. Narin G. Hingorani, "Power Electronics in Electric Utilities: Role of Power Electronics in Future power systems", Proc. Of IEEE, Vol.76, no.4, April 1988.
4. Einar V. Larsen, Juan J. Sanchez-Gasca, Joe H. Chow, "Concepts for design of FACTS Controllers to damp power swings", IEEE Trans On Power Systems, Vol.10, No.2, May1995.
5. Gyugyi L., "Unified power flow control concept for flexible AC transmission", IEEE Proc-C Vol.139, No.4, July1992.

((DEC-I V) -3) Energy Storage Systems

Teaching Scheme	Examination Scheme
Lectures: 3hrs/week	T1, T2–20 marks each,
	End-Sem Exam–60

Course Outcomes:

At the end of the course the students will be able to,

1. Understand the emerging needs of Electrical Energy Storage Systems and their applications.
2. Analyze the performance of various Electrical and Physical Energy Storage Systems.
3. Assess the markets for the Electrical Energy Storage Systems.

Unit- I

Generalities on Energy Storage Systems:

General definitions: Capacity, Depth of Discharge, State of Charge, "Round-Trip" Efficiency under Normal, Ideal, and Real Conditions, Charge and Discharge Losses, Losses due to Self-Discharge, Total Losses, Round-Trip Efficiency, Types of Energy Storage Systems. **(06)**

Unit - II

Electrochemical Energy Storage:

Introduction, Different Types of Accumulators (Batteries), Accumulators with Aqueous Electrolyte, Accumulators with Nonaqueous Electrolyte, Large Size Accumulators, Modeling of Batteries, it's thermal behavior, thermal modeling, battery management systems (BMS), Ageing of electrochemical batteries, ageing behavior: cycling, calendar, complete ageing model

(08)

Unit–III

Energy Storage by Means of Supercapacitors and Superconductive Magnetic Energy Storage Systems (SMES) : Characteristics of Supercapacitors, Principle and Properties, Modeling of Supercapacitors, Design of Supercapacitive bank, Charging and Discharging of Supercapacitors, applications for Power Electronics Converters,Working principle, characteristics, and applications of Superconductive Magnetic Energy Storage Systems (SMES).

(08)

Unit- IV

Physical Systems for Energy Storage:

Introduction, Principle and operation, Classifications, Properties and applications of Energy storage systems based on Compressed air, Hydro and Pumped storage, Flywheel systems **(06)**

Unit- V

Energy Storage based on Hydrogen:
Introduction, Power to power storage system based on Hydrogen, Electrolysis water, Storage Hydrogen, Conversion from Hydrogen to Electricity, Efficiency considerations, conversion from Hydrogen to Electrical power, Conversion from Electrical power to Hydrogen.
(08)

Unit-VI
System Arrangements and Applications:
Storage as Grid component, Storage with PV systems, Microgrid, Hybrid Power plant, Electric vehicle applications, fast-charging stations, Advanced systems architectures, Uninterrupted Power supply.
(06)

Text Books:

1. Energy Storage Systems and Components by Alfred Rufer.
2. IEC White paper on Electrical Energy Systems:
   i *www.iec.ch/whitepaper/pdf/iecWP*

3.Energy Storage Systems, Volume I and II, EOLSS, *www. eolssunesco@gmail.com*

References:

1. Energy Storage for Power Systems by A. Ter-Gazarian, Institution of Engineering and Technology, 2011
2. Electric Energy Storage Systems Flexibility Options for Smart Grids by Przemyslaw Komarnicki • Pio Lombardi • Zbigniew Styczynski.

((DEC-IV)-4) EHV AC Transmission

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

100 marks: Continuous evaluation

Assignments /Quiz/ Test: 40 Marks,

End - Seem Exam: 60 Marks

Course Outcomes:

After the completion of this course, the students will be able to:

1. Perform kinematic and dynamic analyses with simulation.
2. Design control laws for a simple robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given industrial application.

Syllabus contents:

Unit 1

Introduction to EHV AC Transmission [6 Hrs]

Need for EHV transmission lines, Power handling capacity and line loss, Examples on giant power pools and number of lines, Mechanical considerations in line performance, Vibrations Travelling wave equations, transmission reflection attenuation and distortion of travelling waves, transmission and reflection coefficients and examples.

Unit 2 **[6Hrs]**

Calculation of Line and Ground Parameters

Resistance of conductors, effect of temperature on overhead conductors, temperature rise of conductors and current carrying capacity, Properties of bundled conductors, Inductance of current carrying single conductor, Inductance of EHV line configurations, Line capacitance calculations. Sequence inductances and capacitances, Diagonalization.

Unit 3 **[6 Hrs]**

Voltage Gradient of Conductors

Electrostatic, Field of sphere gap, Field of line charges and their properties, charge potential relations for multi-conductor lines, Maximum charge condition on three phase line. Surface voltage gradient on conductors-single conductor, two conductors and multi-conductor bundle, Maximum surface voltage gradient, design of cylindrical cage for corona experiments

Unit 4 **[7 Hrs]**

Corona and its effects

Corona formation, corona inception voltage, visual corona voltage, critical field for corona inception and for visual corona under standard operating condition and conditions other than standard operating conditions. Power loss due to corona, corona loss formulae, corona current waveform, charge-voltage diagram and corona loss, increase in effective radius of conductor and coupling factors, attenuation of travelling waves due to corona loss. Audible noise operation and characteristics limits for audible noise, AN measurement and meters. Formulae for audible noise and use in design, relation between single phase and three phase AN levels.

Unit 5 **[8 Hrs]**

Electrostatic and Magnetic Fields of EHV Lines

Electric shock and threshold currents, Effects of high electrostatic fields on humans, animals and plants, Calculation of electrostatic field of single circuit of three phase line, Profile of electrostatic field of line at ground level. Electrostatic induction on un-energized circuit of a double circuit line. Insulated ground wire and induced voltage in insulated ground wires. Magnetic field calculation of horizontal configuration of single circuit of three phase lines, Effects of power frequency magnetic fields on human health.

Unit 6 **[6 Hrs]**

Design of EHV Lines

Design of EHV lines based upon steady state limits and transient over voltages, design factors under state. Design examples: steady state limits. Line insulation design based on transient over voltages

Text Books:

1. Rakosh Das Begamudre – "Extra High Voltage AC Transmission Engineering", 4th Edition, New Age International, New Delhi, 2011.

Reference Books:

1. S. Rao, "EHV-AC, HVDC Transmission and Distribution Engineering", 3rd Edition, Khanna Publishers, New Delhi, 2009.

((DEC-IV)-5) Industrial Automation And Control

Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	Test 1: 20 Marks
Tutorial: 3 Hrs/Week	Test 2: 20 Marks
	End-Semester Exam: 60Marks

Course Outcomes: Students will be able to

1. Use various sensors for measurement of physical parameters
2. Analyse various control configurations used in process control
3. Use controller such as P, PI, PID
4. Design systems using PLC, SCADA, DDC configuration as control values for application
5. Compare various control valves

Syllabus Contents:

UNIT 1 **[7 Hrs]**

Introduction to Industrial Automation and Control:

Architecture of Industrial Automation Systems, Introduction to sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH etc., Signal Conditioning and Processing

UNIT 2 **[7 Hrs]**

Introduction to process Control:

Evolution of Process Control Concept , Definition and Types of Processes Benefits, Difficulties and Requirements of Process Control Implementation, Classification of Process Variables, Open-loop Vs Closed Loop control, Servo Vs Regulator Operation of Closed Loop System, Feedback and Feed forward Control Configuration, Steps in Synthesis of Control System, process dynamics and Mathematical Modelling, Aspects of the process dynamics, Types of dynamic processes, Common systems, Mathematical Modelling, Cascade, Feedforward, and Ratio Control, multiloop Cascade Control, Feedforward Control, Feedforward- Feedback control configuration, Ratio Controller

UNIT 3

Type of Controllers: [7 Hrs]

Introduction, PID control, Classification of Controllers, Controller Terms, Introduction, Transfer functions of closed loop, Proportional controller in closed loop, Integral controller in closed loop, Proportional-integral controller in closed loop, Proportional derivative controller in closed loop, Proportional-integral-derivative controller in closed loop, Integral wind up and Anti-windup, Comparison of various controller configurations, Controller Tuning

UNIT 4

PLC, DCS and SCADA system: [7 Hrs]

Introduction, Basic parts of a PLC, Operation of a PLC, Basic symbols used in PLC realization, Difference between PLC and Hardwired systems, Difference between PLC and computer, Relay logic to ladder logic, Ladder commands, Examples of PLC ladder diagram realization, PLC timers, PLC counters and examples, Classification of PLCs. History of DCS, DCS concepts, DCS hardware & software, DCS structure, Advantages and disadvantages of DCS, Representative DCS, SCADA, SCADA hardware & software,

UNIT 5

Control Valves: [7 Hrs]

Introduction, Common abbreviations in the valve industry, Definitions of terms associated with valves, Control Valve characteristics, Valve classifications and types, Selection criteria for control valves, P and I diagram, Definitions of terms used in P and I diagrams, Instrument identification, Examples of P and I diagram, various automation devices used in industry, Control of Machine tools, Analysis of a control loop.

UNIT 6

Actuators [7 Hrs]

Introduction to Actuators: Flow Control Valves, Hydraulic Actuator Systems: Principles, Components and Symbols, Pumps and Motors, Proportional and Servo Valves Pneumatic Control Systems, System Components, Controllers and Integrated Control Systems, Electric Drives, Energy Saving with Adjustable Speed Drives.

TEXT BOOKS:

1. S. Mukhopadhyay, S. Sen and A.K. Deb, "Industrial Instrumentation, Control and Automation", Jaico Publishing House.
2. Dobrivojie Popovic, Vijay P. Bhatkar, "Distributed Computer Control for Industrial Automation", Dekker Publications.
3. Webb and Reis," Programmable Logic Controllers: Principles and Applications", PHI.
4. S.K. Singh, "Computer Aided Process Control", PHI
5. Garry Dunning, "Introduction to Programmable Logic Controllers", Thomson Learning.
6. N. E. Battikha, "The Management of Control System: Justification and Technical Auditing", ISA
7. Krishna Kant, "Computer Based Process Control", PHI 7. Fu, Lee, Gonzalez, "Robotic Control, sensing and Intelligence", Tata McGraw-Hill

((DEC-IV)-6) Big Data Analysis

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2 – 20 Marks each
End-Sem Exam – 60 Marks

Course Outcomes

Students will be able to:

1. Explain the need of Big Data, challenges and technology stack of big data.
2. Explain and work on Hadoop Framework and ecosystems.
3. Explain and Analyze Big Data using Map Reduce programming framework in both Hadoop and Apache Spark.
4. Analyze large datasets using Apache Pig.
5. Perform Data Querying and Analysis on large datasets using Apache Hive.

Unit 1

[5 Hrs]

Introduction to Big Data:

Types of Digital Data, Overview of Big Data Analytics, Evolution of Big Data, Characteristics of Big Data - Volume, Variety, Velocity, Veracity, Valence, Value, Applications of Big Data, Challenges with Big data, Introduction to Enabling Technologies for Big Data.

Unit 2

[6 Hrs]

Big Data Technology Stack:

Introduction to Big Data Technology Stack, Overview of Big Data distribution packages, Introduction to Big Data Platforms, Big Data Storage Platforms for Large Scale Data Storage, CAP Theorem, Eventual Consistency, Consistency Trade-Offs, ACID and BASE, Overview of Zookeeper and Paxos, Cassandra.

Unit 3

[8 Hrs]

Apache Hadoop:

History of Hadoop, Overview Apache Hadoop and Apache Spark, Hadoop Storage Framework – Hadoop Distributed File System (HDFS) , HDFS Architecture, HDFS Concept, Hadoop Data Processing Framework – Map Reduce, Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features, MapReduce Programming Model with Spark.

Unit 4

[8 Hrs]

Introduction to Big Data Streaming:

Big Data Pipelines for Real-Time computing, Introduction to Apache Spark Streaming, Kafka, Streaming Ecosystem, Spark Components, Resilient Distributed Dataset and data frames.

Unit 5

[8 Hrs]

Apache PIG:

What is ETL, Introduction to Apache PIG, Execution Modes of PIG, Comparison of PIG with SQL and No-SQL Databases, PIG Data Types, Data Models in PIG, Grunt, PIG Latin, Overview of PIG User Defined Functions

Unit 6

[6 Hrs]

Apache HIVE:

Introduction to Apache Hive, Hive Architecture and components, Hive Metastore, Comparison with Traditional Databases, HiveQL, Hive Partition, Hive Bucketing, Tables(Managed and External)

Text Books

1. "Big Data Analytics", Seema Acharya, SubhasiniChellappan, Second Edition, 2019, Wiley India Pvt.Ltd, ISBN 978-81-2657-951-8.
2. "Hadoop: The Definitive Guide", Tom White, Fourth Edition, 2015, O"Reilly, ISBN 978-93-5213-067-2.

Reference Books

1. “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, Bill Franks, First Edition,2012, John Wiley & sons,ISBN: 978-1- 118-20878-6
2. “Mining of Massive Datasets”, Jure Leskovec, Anand Rajaraman and Jeffrey David Ulman, Second Edition 2016, Dreamtech Press, ISBN - 978-13-1663-849-1
3. “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications”, Bart Baesens, First Edition 2014, Wiley, ISBN: 1118892704
4. “Big Data Glossary”, Pete Warden, First Edition 2011, O“Reily, ISBN
5. “Harness the Power of Big Data The IBM Big Data Platform ",Paul Zikopoulos ,Dirk DeRoos , Krishnan Parasuraman , Thomas Deutsch , James Giles , David Corigan , Annotated Edition 2012, Tata McGraw Hill Publications, ISBN 978-0071808170
6. "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Michael Mineli, Michele Chambers, Ambiga Dhiraj, First Edition 2013, Wiley Publications, ISBN 978-1118147603
7. “BigDataAnalytics: Disruptive Technologies for Changing the Game”, ArvindSathi, MC Press, 2012, ISBN 1583473807

(SBC) Major Project

Teaching Scheme:

Examination Scheme:
100 marks: Continuous Evaluation

Course outcomes:

Students will be able to

1. To formulate problem statement
2. To design basic engineering systems based on problem statement
3. To simulate, fabricate and test the circuit
4. To work in team and to communicate effectively
5. To realize impact on environment

Students will work on the problem statement offered by faculty and students. The student and faculty may collaborate with industry to make it industry relevant.

MINOR COURSES
Electric Machines and Drives

Teaching Scheme:
Lectures: 3 hrs/week
Tutorial: --- hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz/ Test- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:

By the end of the course, students will be able to

1. Analyse the motor drive system for various industrial loads
2. Select and estimate motor rating as per duty of operation
3. Design dc motor control circuitry and select devices for speed and torque
4. Design induction motor control circuitry and select devices for speed and torque
5. Design dc motor control circuitry and select devices for speed and torque
6. Analyse the motor situation during starting and braking.
7. Configure the basic drive system combination as per application

Syllabus Contents:

Unit 1 **[6 Hrs]**
Basics of Electric Drives and Control

Definition, advantages of electrical drives, components of electric drive system, selection factors, types and status of electrical drives, speed control, drive classifications, close loop control of drives, phase locked loop (PLL) control.

Unit 2 **[6 Hrs]**

Dynamics of Electrical Drives

Motor-Load Dynamics, speed torque conventions and multi quadrant operation, equivalent values of drive parameters. Load torque components, nature and classification of load torques, constant torque and constant power operation, steady state stability, load equalization.

Unit 3 [4 Hrs]

Selection of Motor Power Rating

Thermal model of motor for heating and cooling, classes of motor duty, determination of motor ratings for various operation duty cycle.

Unit 4 [6 Hrs]

DC Motor Drives

DC motors and their performance starting, transient analysis, speed control, Ward-Leonard drives, controlled rectifier fed drives, full controlled 3-phase rectifier control of dc separately excited motor, multi quadrant operation, Chopper controlled drives, closed loop speed control of DC motor, starting and braking of dc motors

Unit 5 [6 Hrs]

Induction Motor Drives

Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, slip power recovery – Static Kramer and Schermie's drive, single phase induction motor starting, braking and speed control, introduction of vector control, industrial applications.

Unit 6 [4 Hrs]

Synchronous Motor and Brushless dc Motor Drives

Synchronous motor types, operation with fixed frequency, variable speed drives, vector control, PMAC and BLDC motor drives, Stepper motor drives, switch reluctance motor drives, industrial applications.

Text Books:

1. G. K. Dubey, Fundamentals of Electrical Drives, Second edition (sixth reprint), Narosa Publishing house, 2001

Reference Books:

1. M. H. Rashid, —Power Electronics -Circuits, devices and Applications‖, 3rdEdition, PHI Pub. 2004.
2. B. K. Bose, —Modern Power Electronics and AC Drives‖, Pearson Education, Asia, 2003.

Electrical Power System

Teaching Scheme

Lectures: 3 Hrs/Week

Tutorial: 0Hrs/Week

Examination Scheme

Test 1: 20 Marks

Test 2: 20 Marks

End-Sem Exam: 60 Marks

Syllabus Contents:

Unit 1 **[8 Hrs]**

Generation of Electric Power

Overview of conventional (Hydro, Thermal and Nuclear) and Nonconventional Sources (Solar and Wind) (Block Diagram and Brief Description Only)

Unit 2 **[6 Hrs]**

Economics of Generation

Base load, peak load, Load factor, diversity factor, Load curve (Brief description only) Numerical Problems. Methods of power factor improvement using capacitors

Unit 3 **[8 Hrs]**

Power Transmission

Transmission Line Parameters: Resistance, inductance and capacitance of 1-Φ, 2 wire lines-composite conductors. Inductance and capacitance of 3-Φ lines. Symmetrical and unsymmetrical spacing-transposition-double circuit lines bundled conductors (Derivation Required). Numerical Problems Modelling of Transmission Lines: Classification of lines-short lines-voltage regulation and efficiency-medium lines-nominal T and Π configurations-ABCD constants- long lines- rigorous solution-interpretation of long line equation-Ferranti effect, proximity effect, skin effect, Corona losses.

Unit 4 **[6 hrs]**

Transmission line structures, insulators for overhead lines, string efficiency, Insulated cables, insulating material, grading of cables, capacitance of single core/ three core cable, dielectric loss, HVDC transmission and FACTS technology

Unit 5 **[8 Hrs]**

Distribution system

Distribution of Electrical Energy: D.C and A.C. distribution, radial and ring main distribution, medium voltage distribution network, low voltage distribution network, single line diagram, substation layout, substation equipment's.

Unit 6 **[6 Hrs]**

Substation and grounding:

Types of substation, busbar arrangements, location, equipment's, circuit breaker, isolator, lightning arrestor, current and potential transformers, reactors and capacitors,

Grounding: types, need for grounding, neutral grounding, ungrounded systems.

Books:

1) S. N. Singh: Electric Power Generation, Transmission and Distribution, Prentice-Hall, 2007.

2) L. M. Faulkenberry and Walter Coffer, Electrical Power Distribution and Transmission, 2/e, Pearson Education Inc., 2007.

Utilization of Electrical Power syllabus

Teaching Scheme:	Examination Scheme:
Lectures: 3 hrs/week Field	MCQ-1 and 2: 20 Marks each
Visit: As necessary	End-SemesterExam:60Marks

Course outcomes:

At the end of the course the student will be able to

1. Discuss electric heating, air-conditioning and electric welding.
2. Explain laws of electrolysis, extraction and refining of metals and electro deposition.
3. Explain the terminology of illumination, laws of illumination, construction and working of electric lamps.
4. Design interior and exterior lighting systems- illumination levels for factory lighting- flood lighting street lighting.
5. Discuss systems of electric traction, speed time curves and mechanics of train movement.
6. Explain the motors used for electric traction and their control.
7. Discuss braking of electric motors, traction systems and power supply and other traction systems.
8. Explain the working of electric and hybrid electric vehicles.

Syllabus contents:

Unit 1 **[8 Hrs]**
Heating and welding
Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Air – Conditioning, Electric Welding, Modern Welding Techniques.

Electrolytic Electro – Metallurgical Process:

Ionization, Faraday's Laws of Electrolysis, Definitions, Extraction of Metals, Refining of Metals, Electro Deposition

Unit 2 **[8 Hrs]**
Illumination

Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting.

Unit 3 [8 Hrs]

Electric Traction Speed - Time Curves and Mechanics of Train Movement

Introduction, Systems of Traction, Systems of electric Traction, Speed - Time Curves for Train Movement, Mechanics of Train Movement, Train Resistance, Adhesive Weight, Coefficient of Adhesion.

Motors for Electric traction:

Introduction, Series and Shunt Motors for Traction Services, Two Similar Motors (Series Type) are used to drive a Motor Car, Tractive Effort and Horse Power, AC Series Motor, Three Phase Induction Motor.

Control of motors:

Control of DC Motors, Tapped Field Control or Control by Field Weakening, Multiple Unit Control, Control of Single-Phase Motors, Control of Three Phase Motors.

Unit 4 [8 Hrs]

Braking

Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro – Mechanical Drum Brakes.

Electric Traction Systems and Power Supply

System of Electric Traction, AC Electrification, Transmission Lines to Sub - Stations, Sub – Stations, Feeding and Distribution System of AC Traction, Feeding and Distribution System for Dc Tramways, Electrolysis by Currents through Earth, Negative Booster, System of Current Collection, Trolley Wires.

Trams, Trolley Buses and Diesel – Electric Traction:

Tramways, the Trolley – Bus, Diesel Electric Traction.

Unit 5 [8 Hrs]

Electric Vehicles

Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption.

Hybrid Electric Vehicles

Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Design/ Development of Solutions, Conduct investigations of complex problems, The Engineer and Society, Ethics, Individual and Team Work.

Question paper pattern

1. The question paper will have ten questions.
2. Each full question is for 16 marks.
3. There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
4. Each full question with sub questions will cover the contents under a module.
5. Students will have to answer 5 full questions, selecting one full question from each module.

Textbook

1 A Textbook on Power System Engineering A. Chakrabarti et al Dhanpat Rai and Co 2nd Edition, 2010

2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals Theory, and Design (Chapters 04 and 05 for module 5) Mehrdad Ehsani et al CRC Press 1st Edition, 2005

Reference Books

1 Utilization, Generation and Conservation of Electrical Energy Sunil S Rao Khanna Publishers 1st Edition, 2011

2 Utilization of Electric Power and Electric Traction.

RENEWABLE MINOR

Hydro Energy Systems

Teaching Scheme:
Lectures: 3 hrs./week
Field Visit: As necessary

Examination Scheme:
MCQ-1 and 2: 20 Marks each
End-Semester Exam: 60Marks

Course Outcomes:

Students will be able to:

1. Understand the basics of hydro energy, availability, applications ,various types of small hydro power plants, engineering required for small hydro power plants, environmental impact considerations, introduction to manufacturing of the systems, characterization, quality assurance, standards, certification and economics.
2. A field visits will be designed for first the and experience and demonstration of the system elements.
3. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of multiple choice type or of the type-define, identify, state, match, list, name etc.)
4. Understand basic concepts. (To measure this outcome, questions may be of the type explain ,describe, illustrate, evaluate, give examples, computer etc.)

Syllabus contents:

Unit 1 **[6 Hrs]**
Basics of Hydro Energy and is Availability

Energy in water, basic hydro energy conversion, energy conversion calculations and efficiency, categorization of hydroelectric power plants, viz. micro, small and large, decentralized hydroelectric plants, types of turbines and their applications in small hydro technologies, site requirements for hydropower , availability of sites globally and in India, environmental impact of various capacity hydroelectric plants.

Unit 2 **[6 Hrs]**
Introduction to Small Hydro Power Technologies

Scale of turbines being considered, technologies for small hydro, turbine designs and efficiencies, control systems, safety, design considerations for a small hydro power plant, components of small hydro power plants, stand alone and grid interactive plants, operation and maintenance, standards and certification, manufacturing, quality assurance and testing.

Unit 3 **[8 Hrs]**
Kinetic Energy Turbines

What are kinetic energy turbines, state of the art technologies, design considerations and materials ,testing, site requirements, marine current turbines, in pipe turbines, typical designs for generators, power plants, decentralized hydroelectric plants, modular configuration, and environmental impact.

Unit 4 **[8 Hrs]**
Small Hydro Power Plants

Typical design of small hydro powerplants, design considerations for components, decentralized plants, generator designs, operation and maintenance, site requirements, environmental impact assessment, manufacturing and assembly, quality assurance, standards and certification.

Unit 5 **[8 Hrs]**
Economics of Small Hydro Power Plants

Cost of small hydro power plants, technology wise difference in costing, site development costs, environmental impact costs, life cycle costing, return on investment; impact of scale on the economics.

Unit 6 **[6 Hrs]**
Field Visits

One more of the following visits may be undertake small scale hydro electricity generator system manufacturer small hydro power plant either stand alone or grid connected manufacturer of electronics and control for small hydro plant.

Reference Books:

1. Trainer’s Textbook, Small Hydro Power (SHP) Module, Ministry of New and renewable energy, Government of India
2. Standards/Manuals/Guidelines for Small Hydro Power Development (General 2012, Civil Work 2008), Ministry of New and Renewable Energy, Government of India

3. Small Hydro Handbook, Colorado Energy Office, Denver Colorado, USA
4. Small Hydro Power Plants in Europe: Handbook on Administrative Procedures Requested, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia, 2009
5. Layman's Guidebook on How to Develop Small Hydro Site, European Small Hydropower Association, Brussels,Belgium,1998
6. Handbook of Innovative technologies to Promote SHP, Final Version, European Union, Report on Work Package V, Common Strategies to Improve SHP Implementation,2011

Energy Conservation And Auditing

Teaching Scheme: 3 hrs/week

Examination Scheme: 100 marks
Assignments /Quiz- 40 Marks,
End - Seem Exam – 60 Marks

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Identify, formulate and solve energy related problems in the broad areas like electrical and mechanical installations, electrical machines, power systems.
2. Plan and execute energy management strategies.
3. Perform energy audit and put forward practical solutions for energy conservation.
4. Understand the energy billing and financial aspect in energy audit.

Syllabus Contents:

Unit 1

Energy Scenario **[5 Hrs]**

Energy sources-Primary and Secondary, Commercial and Non-commercial, Energy scenario in India and Global scenario, Energy Security, Energy and GDP, Energy Intensity, Energy conservation and its importance, Energy Conservation Act 2001 and related policies, Role of Non- conventional and renewable energy.

Unit 2

Energy Management and Integrated Resource Planning **[6 Hrs]**

Definition and Objectives of Energy management, Energy management strategy, Key elements, Responsibilities and duties of Energy Manager, Energy efficiency Programs, Energy Monitoring System, Importance of SCADA, Analysis techniques, Cumulative sum of differences (CUSUM)

Unit 3

Energy Audit **[6 Hrs]**

Definition, need of energy Audit, Types of Energy Audit, maximizing system efficiency, Optimizing the input energy requirements, fuel and energy substitution, Energy Audit instruments and metering, thermography, SMART metering

Unit 4

Financial Analysis and Management **[7 Hrs]**

Investment need, financial analysis techniques, Calculation of Simple Pay-back period, return on investment, cash flows, risk and sensitivity analysis, Time value of money, Net Present value, Breakeven analysis, Cost optimization, Cost and Price of Energy services, Cost of Energy generated through Distributed Generation

Unit 5

Energy Efficiency in Electrical Utilities **[7 Hrs]**

Electrical billing, power factor management, distribution and transformer losses, losses due to unbalance and due to harmonics, Demand Side Management, Demand-Response, Role of tariff in DSM and in Energy management, TOU/TOD tariff, Power factor tariff, Integrated Resource Planning and Energy Management Energy conservation in Lighting systems, HVAC, Electric Motors, Pump and Pumping systems

Unit 6

Energy Efficiency in Thermal Systems **[6 Hrs]**

Fuels and combustion, properties of Fuel Oil, coal and gas, storage and handling of fuels, principles of combustion, combustion of oil, coal, gas. Energy efficiency in Boilers, Steam systems, Furnaces, Insulation and Refractors.

Textbooks:

1. Guidebooks for National Certification Examination for Energy Manager/EnergyAuditorsBook-1, General Aspects (available online)
2. Guidebooks for National Certification Examination for Energy Manager/Energy AuditorsBook-2, Thermal Utilities (available online)
3. Guide books for National Certification Examination for Energy Manager / EnergyAuditorsBook-3, Electrical Utilities (available online)
4. Guide books for National Certification Examination for Energy Manager / EnergyAuditorsBook-4,(available online)

Reference Books:

1. S.C. Tripathy, “Utilization of Electrical Energy”, Tata McGrawHill
2. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Bioenergy systems

Teaching Scheme:
Lectures: 3 hrs./week
Field Visit: As necessary

Examination Scheme:
MCQ-1: 20 Marks
Review Project: 20 Marks
End-Semester Exam: 60 Marks

Course Outcomes:

Students will be able to:

1. Understand the basics of biomass to energy, availability of biomass resource, biofuels, organic fertilizers, various types of bioenergy systems, introduction design, development, construction, installation and commissioning of bioenergy systems, measurements and characterization, quality assurance, standards, certification and economics.
2. Field visits will be designed for first-hand experience and demonstration of the system elements.
3. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of multiple choice type or of the type define, identify, state, match, list, name etc.)
4. Understand basic concepts. (To measure this outcome, questions may be of the type explain, describe ,illustrate, evaluate ,give examples, compute etc.)

Syllabus contents:

Unit1 **[6 Hrs]**

Basics of Bioenergy and Resources:

Introduction to bioenergy, biomass availability in India, dealing with agricultural residue, agroindustry residue, environment pollution and biomass, biomass cultivation, biomass and carbon cycle, algae's source of biomass .

Unit2 **[8 Hrs]**

Introduction to Biomass to Energy Technologies:

Biomass burning, gasification of biomass, biomass reforming, anaerobic digestion, types of digesters, biogas purification, biogas bottling, biogas to electricity, aerobic composting, organic fertilizers, biomass to liquid fuel, biodiesel, vegetable oil, biomass refinery, segregated organic waste management.

Unit 3 **[8 Hrs]**

Basics of Key Equipment for Bioenergy:

Size reduction equipment shredder, grinder, pulverizer, hammer mill, mud pump, Solid handling pump, macerator, agitator, hydraulic stirrer, solid-liquid separator, decanter centrifuge, screw press, biogas scrubbing systems, gas compressors, blowers, storage tanks and cylinders , fertilizer processing equipment, piping for biogas and biodiesel ,dehumidifier.

Unit 4 **[8 Hrs]**

Bioenergy for Vehicles and Power Plants:

Biodiesel engines, compressed bio-methane engines, dual fuel engines, multiple fuel engines, vehicular application of bioenergy, biomass gasifier based power plants, biogas power plants with engines and turbines, non-edible waste oil based power generation, biodiesel based electricity generation.

Unit 5 **[6 Hrs]**

Economics of Bioenergy Systems

Lifecycle costing ,holistic payback, calculations, return on investment ; calculations for selection, costing and payback for various bioenergy solutions for applications such as process heating, cooking, vehicle operation, power generation; Environmental impact assessment.

Unit 6 **[4 Hrs]**

Field Visit

One or more of the following visits may be undertaken.

1. Biogas plant for segregated municipal waste
2. Spent wash based biogas plant with purification and bottling facility
3. Biogas fertilizer powerplant
4. Biodiesel manufacturing plant
5. Biomass gasifier based village powerplant

Reference books:

1. Biogas Technology, by B.T. Nijaguna, New Age International, 2006

2. Monitoring the An aerobic Digestion Process, by Harry Michael Falk, thesis for doctor of philosophy in Biochemical Engineering, School of Engineering and Science, Jacob suniversity, Germany, December2011
3. The Biodiesel handbook, Editors Gerhard Knotheetal, A cos Press, Champaign, Illinois, USA
4. Handbook of Biomass Downdraft Gasifier Engine Systems, National Renewable Energy Laboratory, Golden Colorado, USA
5. Various research papers on biogas, biomass gasification and biodiesel
6. Articles from suppliers of various biomass based energy systems,including engines
7. ASTM, DIN and BIS standards