Government College of Engineering,

Chhatrapati Sambhajinagar

(An Autonomous Institute of Government of Maharashtra)

Station Road, Osmanpura, Chhatrapati Sambhaji Nagar – 431005 (M. S.)

Phone – (0240) 2366101, 2366111, Fax (0240) 2332835

Curriculum for M. Tech. in Electrical Power Systems

(NEP Compliant) (With Effect from Academic Year 2023-24)

Vision of the Institute

In pursuit of global competitiveness, the institute is committed to excel in engineering education and research with concern for the environment and society.

Mission of the Institute

Provide a conducive environment for academic excellence in Engineering Education.

Enhance research and development along with promotion to sponsored projects and industrial consultancy.

Foster development of students by creating awareness for needs of society, sustainable development, and human values.

Vision of the Electrical Engineering Department

To develop excellence in Electrical Engineering.

Mission of the Electrical Engineering Department

Impart sound knowledge and technical skills through condutive ambiance with the right attitude towards society and environment.

Enhance research facilities, collaboration with industry and provide testing and consultancy services.

Nurture entrepreneurial qualities, creativity and provide motivation for higher education.

Inculcate teamwork and self-learning.

Program Outcomes

- PO1: An ability to independently carry out research investigations to solve practical problems.
- PO2: An ability to write technical reports/artifacts.
- PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program, and it should be at the level higher than the requirements of the bachelor program.
- PO4: Ability to enhance experiential learning through project-based activities.
- PO5: Formulate and solve real life electrical problems by applying advanced methods.

Govt. College of Engineering, Chhatrapati Sambhaji Nagar
Department of Electrical Engineering
M. Tech Electrical Power Systems (Structure and Syllabus Effective from 2023-24 onward)

Semester I

Semester I Courses				Teaching Scheme			Continuous Evaluation in terms of Marks				
Sr. No.	**Category**	**Course Code**	**Course Name**	**TH**	**T**	**PR**	**Credits**	**ISE I**	**ISE II**	**ESE**	**Total**
1	PCC	EEPCC5001	Digital Protection of Power Systems	3	-	-	3	20	20	60	100
2	PCC	EEPCC5002	Advanced Power Electronics	3	-	-	3	20	20	60	100
3	PCC	EEPCC5003	Electrical Machine Modeling and Analysis	3	-	-	3	20	20	60	100
4	PCC	EEPCC5004	Lab Simulation-I			2	1		25	-	25
	VSEC-I	EEVSE5001	Lab- Power Engineering		1	2	2		25	25	50
5	PEC		PE1	3	-	-	3	20	20	60	100
6	PEC		PE2	3	-	-	3	20	20	60	100
7	ELC	MERMC5001	Research Methodology	4	-	-	4	20	20	60	100
8	CC	INCCC5001	Yoga/Club Activities	-	-	2	-	-	-	-	-
			Total	**19**	**1**	**6**	**22**	**120**	**170**	**385**	**675**

*** List of Program Electives in Semester I**

	***List of Program Electives I, II**		
Course Codes	**Program Electives**	**Course Codes**	**Program Electives**
EEPEC5001	**Power System Planning Operation & Control**	EEPCC6001	Electric Vehicles
EEPEC5002	**Extra High Voltage AC Transmission**	EEPEC6002	PWM Techniques for Power Converters
EEPEC5003	**Power System Reliability**	EEPEC6003	Embedded Systems
EEPEC5004	**Smart Grid Technology**	EEPEC6004	Electromagnetic Interference Techniques
EEPEC5005	**Data Science Applications in Electrical Engineering**		
EEPEC5006	**Computer Aided Power System Analysis**		

Semester II

Semester II Courses				Teaching Scheme			Continuous Evaluation in terms of Marks				
Sr. No.	Category	Course Code	Course Name	TH	T	PR	Credits	ISE I	ISE II	ESE	Total
1	PCC	EEPCC5010	Power Systems Dynamics and Stability	3	-	-	3	20	20	60	100
2	PCC	EEPCC5011	HVDC & FACTs	3	-	-	3	20	20	60	100
3	PCC	EEPCC5012	Lab Simulation -II	-	-	4	2	-	25	25	50
4	PCC	EEPCC5013	Lab Renewable Energy Technology			2	1	-	25	-	25
5	PEC		PE3	3	-	-	3	20	20	60	100
6	PEC		PE4	3	-	-	3	20	20	60	100
7	PEC		PE5	3		-	3	20	20	60	100
8	HSS (AEC)	EEAEC5001	Technical Communication	3	-	-	3	20	20	60	100
9	OE- I	EEOEC5001		3	-	-	3	20	20	60	100
10	VSEC-II	EEVEC5002	Mini Project		-	4	2	-	25	25	50
			Total	**21**	**0**	**10**	**26**	**140**	**215**	**470**	**825**

***List of Program Electives in Semester II**

*List of Program Electives III, IV & V			
Course Codes	**Program Electives**	**Course Codes**	**Program Electives**
EEPEC5011	**Electrical Power Distribution Systems**	EEPCC6011	Advanced Control Systems
EEPEC5012	**Restructured Power Systems**	EEPCC6012	Advanced Electrical Drives
EEPEC5013	**Integration of Renewable Energy Sources**	EEPEC6013	Energy Storage Systems
EEPEC5014	**Life Estimation of Power Equipments**	EEPEC6014	Machine Learning & Applications
EEPEC5015	**Optimization Techniques**		
EEPEC5016	**Smart Appliances & IoT**		
EEPEC5017	**Power Quality and Mitigation**		

Open Elective – I*

*** Equivalent online courses (NPTEL/SWAYAM/MOOC/COURSERA/OTHERS) will be offered and shall be approved by BoS Chairman**

Sr No.	Open Elective – I Course	Course Offering Department
1	AMOEC5001 - Basics of Finite Element Analysis	Applied Mechanics
2	CSOEC5002 - Professional Ethics & Cyber Law	Computer Science & Engineering
3	CEOEC5003 - Engineering Optimization	Civil Engineering
4	MEOEC5004 - Robotics (Not for Mechanical PG Students)	Mechanical Engineering
5	EEOEC5001 – Introduction to Electric Vehicle (Not for Electrical PG Students)	Electrical Engineering
6	ECOEC5006 - IoT for Smart Systems	Electronics & Telecommunication

Semester III

Semester III Courses				Teaching Scheme			Continuous Evaluation in terms of Marks				
Sr. No.	Category	Course Code	Course Name	TH	T	PR	Credits	ISE I	ISE III	ESE	Total
1	DIS	EEDIS5020	Dissertation Ph I			20	10		100	100	200
2	HSS			3			3	20	20	60	100
3	OE- II	EEOEC5002		3	-	-	3	20	20	60	100
4	IKS	INIKS6001	Vedic Approach to Mathematics	2			2	20	10	30	50
			Total	**8**	**0**	**20**	**18**	**60**	**150**	**250**	**450**

Open Elective – II*

*** Equivalent online courses (NPTEL/SWAYAM/MOOC/COURSERA/OTHERS) will be offered and shall be approved by BoS Chairman**

Sr. No.	Open Elective – II Course	Course Offering Department
1	AMOEC6001 - Indian Constitution	Applied Mechanics
2	CSOEC6002 - Data Science (Not for CSE PG Students)	Computer Science & Engineering
3	CEOEC6003 - Disaster Management	Civil Engineering
4	MEOEC6004 - Additive Manufacturing	Mechanical Engineering
5	EEOEC5002 - Energy Audit and Management	Electrical Engineering
6	ECOEC6006 - Soft Computing	Electronics & Telecommunication

HSSM: - Entrepreneurship / Economics / Management Course

Sr. No.	Open Elective – II Course	Course Offering Department
1	MEEEM6001 – Entrepreneurship Development	Mechanical Engineering
2	EEEEM6002 – Engineering Economics	Electrical Engineering
3	MEEEM6003 – Industrial Management	Mechanical Engineering

Semester IV

Semester IV Courses				Teaching Scheme			Continuous Evaluation in terms of Marks				
Sr. No.	**Category**	**Course Code**	**Course Name**	**TH**	**T**	**PR**	**Credits**	**ISE I**	**ISE II**	**ESE**	**Total**
1	DIS	EEDIS5021	Dissertation Ph II	-	-	32	16	-	150	150	300
	Total Second Year			**8**	**0**	**52**	**34**	**60**	**290**	**400**	**750**
2	**Grand Total**			**48**	**1**	**70**	**82**	**320**	**675**	**1255**	**2250**

EEPCC5001: Digital Protection of Power Systems	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits : 03	**Examination Scheme** ISE I (Test) : 20 Marks ISE III : 20 Marks End Semester Exam : 60 Marks

Course Description:

This course is a one-semester course as a mandatory course. It is a course related to use of digital signal processing and other new technologies for power system protection.

Course Objective:

The objectives of the course are to introduce & explain:

1. Advantages of digital relays over conventional relay
2. Understand the concepts related to digital signal processing
3. Develop decision making algorithms for protective relays
4. Design and simulate over current, distance and differential protection schemes for power systems.
5. Apply new technologies for power system protection

Course Outcomes: After completing the course, students will be able to:

CO1	Recognize the advantages of digital relays over conventional relay
CO2	Apply the suitable signal processing techniques for protection
CO3	Understand the adaptive criterion for relay decision making
CO4	Develop the digital protection systems for Transformer and Transmission line
CO5	Identify the new developments in protective relaying and applications.

Detailed Syllabus:

Unit 1	Overview of Static relays, Transmission line protection, Transformer protection, Need for digital protection Digital Relays- Basic elements of a digital relay and their functions, signal conditioning subsystem, conversion subsystem, digital relay subsystem
Unit 2	Signal processing techniques– Sinusoidal based algorithms, Fourier analysis based algorithms, Least squares based algorithm, Discrete Fourier Transforms, Wavelet Transforms, Kalman Filtering
Unit 3	Digital Filters-Infinite Impulse Response Filters, Finite Impulse Response filters Travelling Wave Protection scheme, Digital Protection of Transformers
Unit 4	Correction of errors introduced by Instrument Transformers- PTs and CTs, detection of unsaturated fragment of wave shape, CT saturation correction procedure Decision making in Protective Relays, Adaptive decision schemes
Unit 5	Applications of Fuzzy Logic and ANN for power system protection, Fault location algorithm, Wide Area Monitoring and Protection

Text and Reference Books

1. Computer Relaying for Power Systems, A.G.Phadke, James S.Thorp, John-Wiley and sons, 2009, 2/e.
2. Digital Signal Processing in Power System Protection and Control, Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, Springer Publication, 2011, 1/e.
3. Digital Protection for Power Systems, A.T.Johns and S.K.Salman, IEEE Power Series 15, 1997.
4. Digital Power System Protection, Singh, Prentice-Hall of India Pvt. Limited, 2007, 1/e
1. Understanding Digital Signal Processing, Orhan Gazi, Springer, 2017, 2/e
2. Fundamentals of Power System Protection, Paithankar Y.G, PHI, 2010, 2/e

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ee73/preview
2. NPTEL :: Electrical Engineering - Power System Protection
3. NPTEL :: Electrical Engineering - NOC:Power System Protection and Switchgear

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember			10
K2	Understand	10	10	25
K3	Apply		10	25
K4	Analyze	10		
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Assessment table :

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+K3+K4	K2+K3
	CO1	CO2	CO3	CO4	CO5
ISE I Class Test (20 Marks)	10	10			
ISE III Teachers Assessment (20 Marks)		5	5	5	5
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Dr S P Ghanegaonkar

EEPCC5002 : Advanced Power Electronics	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 20 Marks
Tutorial : 0 Hrs/Week	ISE III : 20 Marks
Credits **:** 03	End Semester Exam : 60 Marks

Course Description:
Advanced Power Electronics is a one-semester course. It is an advanced course related to power electronics.

Course Outcomes:
After completing the course, students will able to:

CO1	Describe structure, characteristics, and applications of advanced power semiconductor devices
CO2	Explain and analyze AC-AC converters
CO3	Explain and analyze DC-AC converters and various control techniques
CO4	Explain and analyze AC-AC converters
CO5	Design of power converters components for various applications

Detailed Syllabus:

Unit-1	Power Semiconductor Devices: Structure, working principle, V-I characteristics, switching characteristics and protection circuits of Thyristors, TRIAC, GTOs, BJT, Power MOSFETS, SIT, IGBT, MCT, IGCT, PIC
Unit-2	**AC-AC Converters:** Single phase and three phase converter, dual converter, converter control, EMI and line power quality problems, phase-controlled cycloconverters, control of cycloconverters, matrix converters, high frequency cycloconverters
Unit-3	**DC-DC converter:** Power factor improvement techniques, Switch mode power converter, Buck, boost, buck boost, Cuk, Fly-back, Forward Converters, operation, modeling, and design of DC-DC converters, Different control strategies of DC-DC converters. Voltage mode and current mode control methods.
Unit-4	**Inverters:** PWM inverters, resonant pulse inverters, series and parallel resonant inverters, Voltage control of resonant inverters, Class E resonant inverter and rectifier, zero current and zero voltage switching resonant converters, resonant DC link inverters, multilevel inverters, diode clamped multilevel inverters, flying capacitor multilevel inverters, cascaded multilevel inverters, applications and features of multilevel inverters, DC link capacitors voltage balancing
Unit-5	**Design of Power Converters Components:** Design of magnetic components - design of transformer, design of inductor and current transformer - Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design

Text Books:

1. M. H. Rashid, “Power Electronics”, PHI publication
2. B.K. Bose, “Power Electronics and AC Drives”, Prentice Hall, 1986
3. Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, Wyley

ISE III Assessment:

Assessments will be based on any one or two of the following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment**	**End Semester Examination**
K1	Remember	05	04	15
K2	Understand	10	04	15
K3	Apply	05	08	15
K4	Analyze		04	10
K5	Evaluate		-	05
K6	Create		-	-
Total Marks: 100		**20**	**20**	**60**

Sample Assessment Table:

Assessment Tool	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3+K4**
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10	-	-	-
Teachers Assessment (20 Marks)	4	4	4	4	4
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Prof. S. S. Mopari

EEPCC5003 : Electrical Machine Modeling and Analysis	
Teaching Scheme	**Examination Scheme**
Lectures: 03 Hrs/Week	ISE I : 20 Marks
Tutorials: 0 Hrs/Week	ISE III : 20 Marks
Credits:03	End Semester Exam : 60 Marks

Course Description:
Electrical Machines modeling and Analysis is a one-semester course where students can opt this course as a professional elective.

Course Objective: The objectives of the course are to master the various fundamentals, machine design, machine modeling of various types of electrical machines. This will help you to gain knowledge and to do research in the area of electrical machine modeling.

The main objective of the course is to:

1. Know the concepts of generalized theory of electrical machines.
2. Model and analyze the electrical machines with voltage, and torque equations.
3. Known the steady state and transient behavior of the electrical machines.
4. Understand the dynamic behavior of the DC/AC, special machines.
5. Learn the issues affecting the behavior of different types of machines such as sudden application of loads, short circuit etc.

Course Outcomes: After completing the course, students will be able to:

CO1	Understand the basic concepts of rotating machine modeling.
CO2	Know and distinguish the different transformations and represent the systems using transformation techniques
CO3	Analyze and model DC machine instate space
CO4	Analyze and model three phase Induction Motor Understand the modeling of induction,
CO5	Analyze and model of synchronous machine modeling, BLDC,PMSM machines

Detailed Syllabus:

Unit 1	**Basic concepts of Modeling:** Basic Principles of Electrical Machine Analysis, Need of modeling, Introduction to modeling of electrical machines
Unit 2	**Concept of transformation:** Commonly Used Reference Frames, change of variables & m/c variables and transform variables for arbitrary reference frames. Stationary Circuit Variables Transformed to the Arbitrary Reference Frame, Transformation Between Reference Frames, and Transformation of a Balanced Set, Balanced Steady State Phasor Relationships , And Balanced Steady State Voltage Equations
Unit 3	**Modeling of Direct-Current Machine:** Voltage and Torque Equations in Machine Variables, Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis, Application to D.C. machine for steady state and transient analysis,

Unit 4	**Modeling of Three phase Induction Machines:** Theory of symmetrical Induction Machines: Voltage and torque in machine variables, model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables, Analysis of steady- state operation, Modeling of 3 phase Induction Motor, Derivation of dq0, Voltage, torque equations, Equivalent circuit, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals.
Unit 5	**Modeling of Three phase Synchronous Machine:** Equations in arbitrary reference frame, Park's transformation, Derivation of dq0 model for a salient pole synchronous machine with damper windings, Torque expression of a salient pole synchronous machine with damper windings and identification of various components. **Modeling Permanent Magnet Synchronous Machine:** Introduction, Types of Permanent Magnet Synchronous Machines, PMAC & PMDC(BLDC) ,Voltage and torque equations in machine variables, voltage and torque equations in rotor reference frame variables

Text and Reference Books:

1. P.C. Krause, "Analysis of Electric Machinery, McGraw Hill", NY, 1987
2. C.V. Jones, "The unified Theory of Electrical Machines", Butterworth,-London, 1967
3. Stevenson, "Power System Analysis", McGraw Hill, NY
4. Dhar R.N., "Computer Aided Power System Operation and Analysis", Tata McGraw Hill
5. P.S. Bhimbra, "The Generalised Theory of Electrical Machines", Tata McGraw Hill
6. B. Adkins & R. G. Harley, "The General theory of AC Machines", Tata McGraw Hill
7. R. Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", PHI Learning Private Limited, New Delhi, 2011.

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems, Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5	10	10
K2	Understand	10	10	20
K3	Apply	5		30
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table

Assessment Tool	K1+K2+ K3	K1+K2+ K3	K1+ K2	K2	K1+K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)				10	10
ESE Assessment (60 Marks)	10	20	10	10	10

Teaching Strategies:
The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

Special Instructions if any: Nil

Designed by
Dr. Sandhya Kulkarni

EEPCC5004: Lab Simulation-I	
Teaching Scheme Practicals: 2 Hrs/Week Credits : 01	**Examination Scheme** ISE III : 25 Marks

Students should perform total **TEN** experiments.

Any 4 from following-

1. Generalized program to determine Y bus of given network.
2. Generalized program to determine load flow of a given network using G-S method.
3. Generalized program to determine load flow of a given network using the N-R method.
4. Generalized program to determine load flow of a given network using FDLF method.
5. Formation of YBUS using two dimensional arrays by inspection method
6. Formation of YBUS using Scarcity Technique
7. Power system load flow of IEEE 6 BUS

Any 3 from following-

1. Familiarization with various features of the Sci-lab / MATLAB/Simulink environment.
2. Demonstrating the phenomenon of aliasing due to under-sampling.
3. Implementation of algorithm s based on undistorted sine wave approximation with Sample and its derivative
4. Implementation of algorithms based on undistorted sine wave approximation with First and second derivative technique
5. Implementation of Differential Equation Algorithm(DEA) by Numerical differentiation
6. Implementation of Sachdev's Least Square Error (LSQ) Algorithm.
7. Implementation of Fourier algorithms using DFT

Any 3 from following-

1. Simulation of DC-DC converters: (i) Buck Converter Boost Converter, and BuckBoost converter.
2. Simulation of single phase and three-phase controlled rectifiers with different loads.
3. Simulation of single phase inverter: (i) Square wave, (ii) Quasi Square wave, (iii) Selective Harmonic Elimination, and (iv) Sine PWM.
4. Simulation of three-phase inverter: (i) 120 Degree conduction, (ii) 180 Degree conduction
5. Simulation of Multi-pulse converter: (i) 12-pulse
6. Simulation of Multi-level inverter: (i) 3-Level
7. Simulation of CUK Converter, Fly back converter, Push-Pull converter and Forward Converter.

EEVSE5001: Lab Power Engineering	
Teaching Scheme	**Examination Scheme**
Tutorial 1 Hr	ISE III : 25 Marks
Practicals: 2 Hrs/Week	**ESE : 25 Marks**
Credits : 02	**Total : 50 Marks**

CO1	Carryout experiments ensuring the safety of equipment and personnel
CO2	Interpret the experimental results by correlating with practical power systems
CO3	Determine electric stress under uniform and non-uniform electric field conditions
CO4	Analyze the performance of different power converters

List of Experiments:

1. Reactive Power Control Using Tap Changing Transformer
2. Regulation and efficiency characteristics of Artificial Transmission Line
3. Determination of Sequence Reactance's of Power System Elements (Alternator & 3- Φ Transformer)
4. Analysis of unbalanced voltages using Symmetrical Component Analyzer
5. Short circuit studies using DC Network Analyzer
6. Calibration of sphere gap arrangement for High voltage measurement using 100kV Test Transformer
7. Determination of String efficiency of simulated string of insulators
8. Measurement of Fault current of Power System Elements (Alternator & 3-Φ Transformer) under unsymmetrical fault conditions
9. Grounding grid design for a two layer soil model using software simulation
10. Breakdown studies on different electrode configurations under various voltage profiles
11. Harmonic analysis of non-linear loads using Power analyzer and its mitigation using passive filters
12. Analysis of DC-DC converters (a) Buck converter, (b) Boost converter, and (c) Buck-Boost converter
13. Closed loop control of Buck and Boost converter
14. Unipolar and bipolar PWM techniques for single-phase half-bridge and full-bridge inverters
15. Single phase Five level cascaded H-Bridge inverter

List of Program Electives I, and II in Semester I

EEPEC5001: Power System Planning Operation & Control	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits: 03	End-Semester Examination : 60 Marks

Course Description: This is an elective course which covers aspects of planning & operation of power systems.

Course Objectives: The objectives of the course are to introduce & explain:
1. Planning & forecasting of loads
2. Methods to determine transmission loss
3. Hydro-Thermal coordination
4. Load frequency & reactive power control
5. Operation & control of interconnected power systems

Course Outcomes: After completing the course, students will able to:

CO1	Explain different planning & load forecasting methods.
CO2	Determine transmission loss using B-coefficients.
CO3	Explain Hydro-Thermal coordination.
CO4	Explain load frequency & reactive power control using various methods.
CO5	Explain functions of SCADA systems in operation & control of interconnected power systems.

Detailed Syllabus:

Unit 1	Objectives of planning – Long and short term planning- Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting
Unit 2	System Interconnection and Integrated Operation, Optimal Generation Scheduling, Representation of Transmission Loss by B-coefficients, Derivation of Transmission Loss formula. Representation of Transmission Loss by Power Flow equations, Optimal Load Flow solution. Inequality constraints
Unit 3	Hydro-thermal coordination-Hydroelectric plant models –short term hydrothermal scheduling problem - gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming
Unit 4	Automatic Generation and Voltage Control, Load Frequency Control (Single Area and Two Area Load Case) and Economic Dispatch Control, Basic Concepts of Load Dispatch Centers, Functions of Energy Management Centers, Emergency and Restoration of Power System, Automatic Voltage Control, Load Frequency Control with GRCS, Digital LF Controllers, Decentralized Control. Reactive Power Control, Methods for Reactive Power Control
Unit 5	Operation and Control of Interconnected Power System, Functions of SCADA System, Common Features to All SCADA System, Alarm Function, Integration of Measurement, Control and Protection Functions by SCADA System, SCADA Configuration, Distribution Automation and Control

Text and Reference Books

1. R.N. Sullivan, "Power System Planning" , Tata McGraw Hill
2. A.S. Pabla, "Electrical Power System Planning", Mc Millan India Ltd.
3. L.K. Khirchmayer, "Economic operation of Power System", Wiley Eastern Ltd.
4. P.S.R. Murty, "Power System Operation & control", Tata McGraw Hill
5. I. J. Nagrath, D.P.Kothari, "Modern Power System Analysis", Tata McGraw Hill
6. S. Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Khanna Publishers
7. Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley &Sons, Inc., New York.

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		10
K2	Understand	10	10	30
K3	Apply	5	10	20
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K1+K2	K2+K3	K2+K3	K2+K3	K2+K3
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)			5	10	5
ESE Assessment (60 Marks)	12	12	12	12	12

Special Instructions if any:

EEPEC5002: Extra High Voltage AC Power Systems	
Teaching Scheme	**Examination Scheme**
Lectures: 03 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits: 03	End Semester Exam : 60 Marks

Course description:
This course introduces the concepts of **EHV AC Transmission System** & covers the various aspects of **EHV AC Power System.**

Course Objectives: The objectives of the course are to

1. Understand the basic aspects of A.C. power transmission
2. Learn Reflection and Refraction of Traveling Waves
3. Learn various causes for over voltages

Course Outcomes: After completing the course, students will able to:

CO1	Enlist methods of measurement of electrostatic field
CO2	Explain lightning phenomenon and lightning protection.
CO3	Explain the causes of switching surges
CO4	Explain the methods of reactive power control
CO5	Determine magnitude of maximum power angle at voltage stability limit

Detailed Syllabus:

Unit-1	Basic Aspects of A.C. Power Transmission: line trends and preliminary aspects of A.C. Power Transmission, Power-Handling Capacity and Line Loss, standard transmission voltages, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference.
Unit-2	Traveling Waves and Standing Waves: Line Energization with Trapped - Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection Lightning & Lightning Protection, Insulation Coordination Based on Lightning
Unit-3	Over Voltages in EHV Systems: Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Control of Power Frequency Voltages and switching Over Voltages, Power Circle Diagram.
Unit-4	Reactive Power Flow and Voltage Stability in Power Systems: Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post- Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability

Unit-5	Power Transfer at Voltage Stability Limit of EHV Lines: Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit

Text and Reference Books:

1.A. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,"Performance, operation & control of EHV power transmission system " , wheeler publications

2.Rakosh Das Begamudre," Extra high-voltage A.C. transmission Engineering" New Age International Pvt. Ltd.

3.S. Rao, "EHVAC & HVDC Transmission Engineering & Practice" , Khanna Publications

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Assignments
2. MCQ
3. Quiz

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Class Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	05		25
K2	Understand	10	10	25
K3	Apply	05	10	10
K4	Analyze			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K1+K2+ K3	K1+K2+ K3	K1+K2+ K3	K1+K2	K1+K2
	C01	C02	C03	CO4	CO5
Class Test (20Marks)	10	10			
Teachers Assessment (20 Marks)	04	04	04	04	04
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by Dr. V. A. Kulkarni

EEPEC5003 : Power System Reliability			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE I	: 20 Marks
Tutorials	: 0 Hr/Week	ISE III	: 20 Marks
Total Credits	: 3	End Semester Exam	: 60 Marks

Course Description:
Power System Reliability is a one-semester course as elective to post graduates of Electrical Engineering students. It is the fundamental course related to condition of reliability of power system

Course objectives:
The objectives of the course are to
1. Study the fundamentals of Generation system, Transmission system and Distribution system reliability analysis
2. Provide comprehensive knowledge on the various aspects of reliability of power system equipments
3. Explain methods of determination of risk indices and system reliability evaluation
4. Knowledge of assessing reliability of single and multi-area

Course Outcomes: After completing the course, students will be able to:

CO1	Understand the importance of maintaining reliability of power system components
CO2	Apply the probabilistic methods for evaluating the reliability of generation and transmission systems
CO3	Assess the different models of system components in reliability studies..
CO4	Assess the reliability of single area and multi area systems
CO5	Explain reliability of different power system equipments

Detailed Syllabus:

Unit 1	**Generating system reliability analysis I** Generation system model, capacity outage probability tables, Recursive relation for capacitive model building, sequential addition method, unit removal, Evaluation of loss of load and energy indices
Unit 2	**Generating system reliability analysis II** Frequency and Duration methods, Evaluation of equivalent transitional rates of identical and non-identical units, Evaluation of cumulative probability and cumulative frequency of non- identical generating units , level daily load representation, merging generation and load models
Unit 3	**Basic concepts of risk indices:** PJM methods, security function approach, rapid start and hot reserve units, Modeling using STPM approach. Bulk Power System Reliability Evaluation: Basic configuration, conditional probability approach, system and load point reliability indices, weather effects on transmission lines, Weighted average rate and Markov model, Common mode failures.

Unit 4	**Analysis Probability array method:** Two interconnected systems with independent loads, effects of limited and unlimited tie capacity, imperfect tie, Two connected Systems with correlated loads, Expression for cumulative probability and cumulative frequency. Distribution System Reliability Analysis – I (Radial configuration): Basic Techniques, Radial networks, Evaluation of Basic reliability indices, performance indices, load point and system reliability indices, customer oriented, loss and energy oriented indices
Unit 5	**Reliability analysis of different power system equipment:** Inclusion of bus bar failures, scheduled maintenance, temporary and transient failures, common mode failures, Substations and Switching Stations: Effects of short-circuits, breaker operation, Open and Short-circuit failures, Active and Passive failures, switching after faults, circuit breaker model, preventive maintenance, exponential maintenance times. Transmission System Reliability Evaluation and Composite Reliability Evaluation: Average interruption rate method, Stormy and normal weather effect, The Markov process approach, Two plant single load composite system reliability analysis

Text and Reference Books

1. Reliability Evaluation of Power Systems by Roy Billinton and Ronald N. Allan, Plenum press, New York and London (Second Edition), 1996.
2. Reliability Modeling in Electric Power Systems by J. Endrenyi, John Wiley and Sons, 1978
3. Electric Energy System Theory by O.I. Elgerd McGraw Hill Higher Education; 2nd edition
4. Power system Analysis by Stevenson and Grainger , McGraw Hill Education; 1 edition
5. Power System Planning by R. L. Sullivan ,Mc-Graw Hill International book company
6. Reliability Modelling in Electric Power Systems by J.Endrenyi A Wiley-Interscience Publication. Author, *J. Endrenyi*. Edition, illustrated. Publisher, Wiley, 1979.
7. Power System Control & Stability by P. Kundur *McGraw-Hill* Education; 1st edition

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	Test	Teachers Assessment/ Assignment	End Semester Examination
K1	Remember	5	10	10
K2	Understand	10	10	20
K3	Apply	5		30
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Assessment Table :

Assessment Tool	K1+K2	K2+ K3	K2+ K3	K1+K2	K1+K2+ K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	5	5		
Teachers Assessment (20 Marks)				10	10
ESE Assessment (60 Marks)	10	20	10	10	10

EEPEC5004 : Smart Grid Technology	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hrs/Week Credits : 03	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End-Semester Examination : 60 Marks

Course Description: This course introduces the concepts of smart grid technology & covers the various aspects of smart grid.

Course Objectives:

The objectives of the course are to:

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understand concept of power quality issues in Smart grid
5. Appreciate problems associated with integration of distributed generation & its solution through smart grid

Course Outcomes:

After completing the course, students will able to:

CO1	Differentiate between smart grid & conventional grid
CO2	Explain smart grid technologies
CO3	Explain the concept of micro grid & issues of micro grid interconnection
CO4	Identify the power quality issues in Smart grid
CO5	Explain different Communication Technology for Smart Grid

Detailed Syllabus:

Unit 1	Introduction to Smart Grid: Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – Key Challenges for Smart Grid -International policies in Smart Grid. Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid.
Unit 2	Tools and Techniques for Smart Grid: The fundamental components of Smart Grid designs – Transmission and substation Automation – Distribution Automation – Renewable Integration Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.
Unit 3	Distribution Generation Technologies: Introduction to Renewable Energy Technologies – Micro grids- Concept and need, issues of interconnection, – Storage Technologies – Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

Unit 4	Communication Technologies and Smart Grid: Introduction to Communication Technology – Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IOT)- Applications of IOT in Smart Grid Home Area Network (HAN), Neighborhood Area Network (NAN), Advanced Metering Infrastructure (AMI), CLOUD Computing, Cyber Security for Smart Grid
Unit 5	Control of Smart Power Grid System: Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – protection of micro grid, – Reactive Power Control in Smart Grid. Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid.

Text and Reference Books

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
3. JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley Blackwell
5. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7)

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems, 3. Quiz, 4. MCQ

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		10
K2	Understand	10	10	30
K3	Apply	5	10	20
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Assessment Table :

Assessment Tool	K1+K2	K2+K3	K2+K3	K2+K3	K2+K3
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)			5	10	5
ESE Assessment (60 Marks)	12	12	12	12	12

Special Instructions if any:

Designed by
Dr. S.P Gghanegaonkar

EEPEC5005 :Data Science Applications in Electrical Engineering	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 3	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End-Semester Examination : 60 Marks

After the completion of course the students will be able to-

CO1	Distinguish between Algorithmic based methods and Knowledge based Methods
CO2	Able to distinguish between Artificial Neural Networks and Fuzzy Logic
CO3	Adopt Soft Computing techniques for solving Power System Problems
CO4	Apply appropriate AI frame work for solving Power System Problems

Detailed Syllabus

Unit I	**Artificial Neural Networks (ANN):** Introduction to Artificial Neural Networks - Definition and Fundamental concepts -Biological Neural Network – Modeling of a Neuron -Activation functions – initialization of weights - Typical architectures-Leaning/Training laws - Supervised learning Unsupervised learning – Reinforcement learning-Perceptron – architectures-Linear Separability – XOR Problem - ADALINE and MADALINE
Unit II	**ANN Paradigms:** Multi-layer perceptron using Back propagation Algorithm (BPA) -Self – Organizing Map (SOM) -Learning Vector Quantization (LVQ) - Radial Basis Function Network -Functional link network -Hopfield Network - Bidirectional Associate Memory (BAM)
Unit 3	**Deep Learning:** Deep Architectures – Convolution Neural Networks – Convolution Layer – Pooling Layer – Normalization Layer- Fully Connected Layer – Deep belief Networks
Unit 4	**Fuzzy Logic:** Introduction-Classical and Fuzzy sets- Properties, Operations and relations-Fuzzy sets-Membership functions-Basic Fuzzy set operations -Properties of Fuzzy sets-Fuzzy Cartesian Product-Operations on Fuzzy relations-Fuzzy logic-Fuzzy Cardinalities-Fuzzy Logic Controller (FLC): Fuzzy Logic System Components: Fuzzification-Inference Engine-Defuzzification methods
Unit V	**Applications of ANN and Fuzzy Logic:** Load flow studies-Economic load dispatch- Load frequency control- Single area system and two area systems - Reactive power control - Speed control of DC and AC Motors. Fuzzy control applications in wide area control-ANN in hybrid state-estimation- ANN applications for power system protection.

EPSPEC5006: Computer Aided Power System Analysis	
Teaching Scheme	**Examination Scheme**
Lectures : 02 Hrs/Week	ISE I(Test) : 20 Marks
Tutorial : 01 Hr/Week	ISE III : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description: This is an elective course which covers fault analysis, different power flow methods & state estimation techniques of power systems.

Course Objectives:

The objectives of the course are to:

1. Understand graph theory for power system applications.
2. Develop and solve the positive, negative and zero sequence network for a given system for different faults
3. Formulate the power flow problems using load flow methods.
4. Understand large scale power systems solution techniques.
5. Understand large scale power systems solution techniques

Course Outcomes:

After completing the course, students will able to:

CO1	Determine impedance & admittance matrix of a given system
CO2	Draw the sequence network for a given system
CO3	Estimate Fault currents under different fault conditions
CO4	Determine power flow for a given system
CO5	Apply sparse matrix techniques to solve large power systems

Detailed Syllabus:

Unit 1	**Network Modeling:** System graph, Primitive network and matrix, Formation of Y-Bus by Direct inspection, and singular transformation. Bus Impedance Algorithm: Building Block algorithm for bus impedance matrix, Addition of links, addition of branches, (considering mutual coupling), modification of bus impedance matrix for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron's reduction)
Unit 2	**Computer Solution of Power Flow Problem Using GS Method:** Power-Flow Problem, Gauss-Seidel iterative method for solution of nonlinear simultaneous equations. Bus admittance matrix and solution of power flow problem using Gauss-Seidel method. Types of buses. Treatment for Generator bus. Numerical example using computer programming tool.
Unit 3	**Computer Solution of Power Flow Problem using NR method and FDLF:** Newton - Raphson method for solution of non-linear simultaneous equations, Solution of power flow problem using NR method. Decoupled Power Flow Method. Numerical example using computer programming tools.
Unit 4	**Analysis of symmetrical & unsymmetrical Faults:** Symmetrical components, Sequence Impedances of Transmission Lines, Sequence Impedance of Synchronous and Induction Machines, Transformers, Three Winding Transformers. Shunt Faults, Shunt Fault Calculations, Series Faults,

Unit 5	**Sparse Matrix techniques for large scale power systems:** Optimal ordering schemes for preserving sparsity, Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bi-factorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices

Text and Reference Books

1. J. J. Grainger and W.D. Stevenson, *Power System Analysis*, McGraw Hill, 1994
2. G.W. Stagg and A. H. EI-Abiad, *Computer methods in Power System Analysis*, McGraw Hill 1968
3. I.J. Nagrath and D.P. Kothari, *Modern Power System Analysis*, Tata McGraw Hill, 1980
4. G.L.Kusic, *Computer Aided Power Systems Analysis*, Prentice Hall, 1986
5. Pai, M.A., *Computer Techniques in Power System Analysis*, Tata McGraw hill, New Delhi, 2006.
6. P.S.R. Murty, *Power System Operation & control*, Tata McGraw Hill
7. L.K. Khirchmayer, *Economic operation of Power System*,Willey Eastern Ltd.
8. Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., New York.

ISE III Assessment:

Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

3. Presentation on latest topics/Real life problems related with the subject
4. Simulations problem
5. Quiz
6. MCQ

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**ISE III Assessment**	**End Semester Examination**
K1	Remember			
K2	Understand	10		20
K3	Apply	10	10	20
K4	Analyze		10	20
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K2+K3+K4	K2+K3	K2+K3	K2+K3+K4	K2+K3
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)			10	5	5
ESE Assessment (60 Marks)	12	12	12	12	12

EPCC6001: Electric Vehicles			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 0	ISE III	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Nil

Course description: This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. Various aspects of hybrid and electric vehicles such as their configuration, types of electric machines that can be used, energy storage devices, etc. will be covered in this course.

Course Objectives: The objectives of the course are to introduce and explain
The concepts of electrical vehicles and their operation.

1. The basic components of the EV and their design.
2. Power converters & energy storage devices for electrical vehicles

Course Outcomes : After completing the course, students will able to:

CO1	Explain the operation of electrical vehicles.
CO2	Explain Power Converters for Electric and hybrid Vehicles
CO3	Identify the Electrical Machines for Electric and hybrid Vehicles
CO4	Design the components of the electrical vehicles.
CO5	Describe different Energy Storage options for the Electric and hybrid Vehicles

Detailed Syllabus:

Unit 1	History of electric & hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Dynamics of the electric and hybrid electrical vehicles- motion and dynamic equation for vehicles, Vehicle Power Plant and Transmission Characteristics, Basic Architecture of Hybrid Drive Trains and Analysis of Series Drive Train, Power Flow in HEVs, Torque Coupling and Analysis of Parallel Drive Train, Basic Architecture of Electric Drive Trains
Unit 2	Power Converters- DC-DC converters for EV and HEV applications, DC-AC converters in EV & HEV
Unit 3	AC Electrical Machines for hybrid and Electric Vehicles- Induction motors, Permanent Magnet Motors. SRM motors, their control and applications in EV/HEV
Unit 4	Design of Electrical EV/HEV – Principles, Drive cycles and its detail analysis, sizing of electrical machines. Different test bench setups for emulating EV on-road conditions.

Unit 5	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text and Reference Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", WIELY USA, 2012.
2. Chris Mi, M. Abdul Masrur & David Wenzhong Gao , "Hybrid Electric Vehicles: Principles and Applications with practical perspective", WIELY, 2011
3. Electric Cars The Future is Now!: Your Guide to the Cars You Can Buy Now and What the Future Holds, by Arvids Linde, Veloce Publishing,2010.
4. Abu-Rub, Malinowski and Al-Haddad, "Power Electronics for renewable energy systems, transportation, Industrial Applications", WILEY, 2014.
5. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", Second Edition (Power Electronics and Applications Series) by CRC Press, 2009
6. John Miller, " Propulsion Systems for Hybrid Vehicles," Institute of Electrical Engineers, UK, 2004
7. C.M. Jefferson & R.H. Barnard, " Hybrid Vehicle Propulsion," WIT Press, 2002
8. Iqbal Husain, "Electric and Hybrid Vehicles – Design Fundamentals," CRC Press, 2010
9. James Larminie and John Lowry, " Electric Vehicle Technology Explained, " Oxford Brookes University, Oxford, UK, 2003

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. MCQ
3. Simulation problems, 4. Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Class Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	10	04	10
K2	Understand	05	04	20
K3	Apply	05	04	30
K4	Analyze	-	04	-
K5	Evaluate	-	04	-
K6	Create	-	-	-
Total Marks: 100		20	20	60

Sample Assessment Table :

Assessment Tool	K1+K2+ K3	K1+K2+K3	K1+ K2	K1+K2+ K3+K4	K1+K2+K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	10	-	-	-
Teachers Assessment (20 Marks)	04	04	04	04	04
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Prof. V. P. Dhote

EEPEC6002: Pulse Width Modulation Techniques for Power Converters	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 20 Marks
Tutorial : 0 Hrs/Week	ISE III : 20 Marks
Credits **:** 03	End Semester Exam : 60 Marks

Course Description:
Pulse Width Modulation Techniques for Power Converters is a one-semester course. It is an advanced course related to PWM techniques for Power Converters.
Course Objectives: The objectives of the course are to-
1. Necessity and importance of PWM techniques.

2. To learn different PWM technique to reduce losses and torque ripple

Course Outcomes:
After completing the course, students will able to:

CO1	Appreciate importance of PWM techniques
CO2	Implement PWM using different strategies
CO3	Analysis of line current ripple and dc link current
CO4	Analysis of torque ripple, Inverter loss and Effect of inverter dead-time effect
CO5	Over-modulation and PWM for multilevel inverter

Detailed Syllabus:

Unit-1	Power electronic converters for dc-ac and ac-dc power conversion: Electronic switches, dc-dc buck and boost converters, H-bridge, multilevel converters – diode clamp, flying capacitor and cascaded-cell converters; voltage source and current source converters; evolution of topologies for dc-ac power conversion from dc-dc converters. Purpose of pulse width modulation: Review of Fourier series, fundamental and harmonic voltages; machine model for harmonic voltages; undesirable effects of harmonic voltages – line current distortion, increased losses, pulsating torque in motor drives; control of fundamental voltage; mitigation of harmonics and their adverse effects
Unit-2	Pulse width modulation (PWM) at low switching frequency: Square wave operation of voltage source inverter, PWM with a few switching angles per quarter cycle, equal voltage contours, selective harmonic elimination, THD optimized PWM, off-line PWM. Triangle-comparison based PWM: Average pole voltages, sinusoidal modulation, third harmonic injection, continuous PWM, bus-clamping or discontinuous PWM Space vector based PWM: Space vector concept and transformation, per-phase methods from a space vector perspective, space vector-based modulation, conventional space vector PWM, bus-clamping PWM, advanced PWM, triangle-comparison approach versus space vector approach to PWM

Unit-3	Analysis of line current ripple: Synchronously revolving reference frame; error between reference voltage and applied voltage, integral of voltage error; evaluation of line current ripple; hybrid PWM for reduced line current ripple. Analysis of dc link current: Relation between line-side currents and dc link current; dc link current and inverter state; rms dc current ripple over a carrier cycle; rms current rating of dc capacitors.
Unit-4	Analysis of torque ripple: Evaluation of harmonic torques and rms torque ripple, hybrid PWM for reduced torque ripple. Inverter loss: Simplifying assumptions in evaluation of inverter loss, dependence of inverter loss on line power factor, influence of PWM techniques on switching loss, design of PWM for low inverter loss. Effect of inverter dead-time effect: Requirement of dead-time, effect of dead-time on line voltages, dependence on power factor and modulation method, compensation of dead-time effect.
Unit-5	Over modulation: Per-phase and space vector approaches to over modulation, average voltages in a synchronously revolving *d-q* reference frame, low-frequency harmonic distortion. PWM for multilevel inverter: Extensions of sine-triangle PWM to multilevel inverters, voltage space vectors, space vector based PWM, analysis of line current ripple and torque ripple

Text Books:

1. D. Grahame Holmes, Thomas A. Lipo, "Pulse width modulation of Power Converter: Principles and Practice", John Wiley & Sons,03-Oct-2003

2. Bin Wu, "High Power Converter", Wiley Publication

Reference Books:

1. Marian K. Kazimicrczuk, "Pulse width modulated dc-dc power converter", Wiley Publication
2. IEEE papers

ISE III assessment:

Assessments will be based on any one or two of the following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment**	**End Semester Examination**
K1	Remember	05	04	15
K2	Understand	10	04	15
K3	Apply	05	08	20
K4	Analyze		04	10
K5	Evaluate		-	-
K6	Create		-	-
Total Marks: 100		**20**	**20**	**60**

Sample Assessment Table:

Assessment Tool	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3+ K4**
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10	-	-	-
Teachers Assessment (20 Marks)	4	4	4	4	4
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Prof. V.P.Dhote

EEPEC6003 Embedded Systems			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 0 Hr/Week	ISE III	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Course Description:

The goal of the course is to teach the concepts of Embedded platform, understand related programming PIC architecture and peripheral interfacing. To read and understand C and C++ programming, the course focuses on how to write programs and develop the applications.

Course Objectives: The objectives of the course are to

1. Introduce to the architecture of embedded system
2. Explain various devices and communication system in network
3. Explain programming concept in C++
4. Explain real time operating concept
5. Explain the case studies in RTOS

Unit wise Course Outcomes expected:

Students will be able to

CO1. Explain the embedded system concepts and architecture of embedded systems
CO2. Apply various signal conditioning devices for various applications using microcontroller
CO3. Identify, Test and debug peripherals and related applications in embedded platform.
CO4. Write assembly language program for PIC microcontroller to interface peripherals
CO5. Debug and write the I/O and timers/counter programming

Detailed Syllabus:

Unit-I	**Introduction: Embedded system introduction:** Introduction to embedded system, embedded system architecture, classifications of embedded systems, challenges and design issues in embedded systems, fundamentals of embedded processor and microcontrollers, CISC vs. RISC, fundamentals of Vonuman/Harvard architectures, types of microcontrollers, selection of microcontrollers.
Unit-II	Signal Conditioning: Signal Conditioning & Various Signal Chain Elements, Critical Specifications, How to smartly choose elements from wide choice available in market. Various elements include OPAMPs, Comparators, Instrumentation OP AMPs, ADCs, DACs, DC-DC Converters, Isolators, Level Shifters, ESD Protection Devices.

Unit-III	Memory Systems: On Chip, Memory Subsystem, Bus Structure, Interfacing Protocol, Peripheral interfacing, Testing & Debugging, Power Management, Software for Embedded Systems, Design of Analog Signal Chain from Sensor to Processor with noise, power, signal bandwidth, Accuracy Considerations. Concurrent Programming. Real Time Scheduling, I/O Management, Embedded Operating Systems. RTOS, Developing Embedded Systems, Building Dependable Embedded Systems.
Unit-IV	PIC Architecture: Introduction to PIC microcontrollers, PIC architecture, comparison of PIC with other CISC and RISC based systems and microprocessors, memory mapping, assembly language programming, addressing modes, instruction set.
Unit-V	I/O Programming PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and waveform generation, I/O programming, LEDs, 7 segment LEDs, LCD and Keypad interfacing.

Text/References:

1. Rajkamal, *"Embedded Systems Architecture, Programming and Design"*, TMH, 2003

2. WyneWoff "Principles of Embedded computing System Design", Morgan Koffman publication 2000

3. Steve Heath, *"Embedded Systems Design"*, Second Edition-2003, Butterworth- Heinemann.

4. David E.Simon, *"An Embedded Software Primer"*, Pearson Education Asia, First Indian Reprint 2000

5. Wayne Wolf, "Computers as Components; Principles of Embedded Computing System Design", Harcourt India, Morgan Kaufman Publishers

ISE III Assessments: It is based on one of the /or combinations of the few of the following.

1. Multiple choice question, 2. PPT presentation, 3. Assignments

3. Assessment table:

Assessment Tool					
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 20 Marks	10	10			
Teachers Assessment 20 Marks		05	05	05	05
ESE Assessment 60 Marks	12	12	12	12	12

4. Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test 1**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	05		12
K2	Understand	05	10	12
K3	Apply	10	10	26
K4	Analyze			
K5	Create			10
Total		20	20	60

Designed by: Dr. S. S. Kulkarni

EEPEC6004: Electromagnetic Interference and Compatibility	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits : 03	**Examination Scheme** ISE I Test : 20 Marks ISE III : 20 Marks End Semester Exam : 60 Marks

The students will be able to

CO1	Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems
CO2	Assess the insertion loss and design EMI filters to reduce the loss
CO3	Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits
CO4	Develop suitable techniques to mitigate EMI/EMC issues in power converters

Detailed Syllabus

Unit I	**Introduction:** Sources of conducted and radiated EMI, EMC standardization and description, measuring instruments, conducted EMI references, EMI in power electronic equipment: EMI from power semiconductors circuits.
Unit II	**Noise suppression in relay systems:** AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites
Unit III	**EMI filter elements:** Capacitors, choke coils, resistors, EMI filter circuits. Ferrite breeds, feed through filters, bifilar wound choke filter, EMI filters at source, EMI filter at output EMI filter design for insertion loss: Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils, IEC standards on EMI
Unit IV	**EMI in Switch Mode Power Supplies**: EMI propagation modes, power line conducted-mode inference, safety regulations (ground return currents), Power line filters, suppressing EMI at sources, Line impedance stabilization network (LISN), line filter design, common-mode line filter inductors- design & example, series –mode inductors and problems, EMI measurements.
Unit V	**Faraday Screens for EMI prevention:** As applied to switching devices, transformers faraday screen and safety screens, faraday screens on output components, reducing radiated EMI on gapped transformer cores, metal screens, electrostatic screens in transformers

Text Books & Reference Books:

1. Electromagnetic Compatibility in Power Electronics, Laszlo Tihanyi, IEEE Press, 1995, 1st Edition.
2. Practical Design for Electromagnetic Compatibility, Ficchi, Rocco F., Hayden Book Co., 1981.
3. Handbook on Switch-Mode power supplies, Keith H Billings, Taylor Morey, McGraw-Hill, Publisher, 2011, 3rd Edition.
4. Switching Power Supply Design, Abraham I. Pressman, Keith Billings, Taylor Morey, McGraw Hill International, 2009, 3rd Edition.

Online Resources:1. https://nptel.ac.in/courses/108/106/108106138/

2. Teacher Assessments: Teacher's Assessment based on one of the /or combinations of the few of the following.

1. Multiple choice question, 2. PPT presentation, 3. Assignments

3. Assessment table:

Assessment Tool					
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 20 Marks	10	10			
Teachers Assessment 20 Marks		05	05	05	05
ESE Assessment 60 Marks	12	12	12	12	12

4. Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test 1**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	05		12
K2	Understand	05	10	12
K3	Apply	10	10	26
K4	Analyze			
K5	Evaluate			
K6	Create			10
Total		20	20	60

Designed by:
Dr. S. S. Kulkarni

MERMC5001: Research Methodology	
Teaching Scheme	**Examination Scheme**
Lectures: 4 Hrs/Week	ISE I Test : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits : 04	End Semester Exam : 60 Marks

Course Objectives:

1. To guide students from understanding foundational research concepts to critically formulating research problems, culminating in the adept creation of comprehensive research plans and literature reviews.
2. To develop a comprehensive understanding of various research methods, both qualitative and quantitative
3. To facilitate students in analyzing, evaluating, and creating research proposals.
4. To attain mastery in data collection methods, sampling, data analysis techniques, and result interpretation for robust research outcomes.
5. To Equip students with the skills to proficiently create and present diverse research reports, encompassing various formats, oral delivery, technical writing, and ethical awareness regarding plagiarism.

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Develop the ability to comprehend core research concepts, define key elements like variables and hypotheses, and critically evaluate literature to identify research gaps.
CO2	Justify their chosen research methods and explain their advantages and limitations.
CO3	Create well-structured research proposals that include clear research objectives, methods, and expected outcomes.
CO4	Proficient in using data analysis techniques relevant to their chosen research methods, such as statistical analysis for quantitative research or thematic analysis for qualitative research.
CO5	Create comprehensive research reports in diverse formats, such as academic papers, presentations, and technical reports.

Detailed Syllabus

Unit 1	**Introduction to RM:** Meaning of Research, Objectives of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Defining the Research Problem, Selecting the Problem, Technique Involved in Defining a Problem, Research Design, Important Concepts Relating to Research Design, Developing a Research Plan, Literature review.
Unit 2	**Methods of Research:** Qualitative and quantitative methods of research like Historical, case study, ethnography, exposit facto, documentary and content analysis, survey (Normative, descriptive, evaluative etc.) field and laboratory experimental studies. Characteristics of methods and their implications in the research area.
Unit 3	**Development of research proposal:** Research proposal and its elements Formulation of research problem-criteria of sources and definition Development of objectives and characteristics of objectives. Development hypotheses and applications.
Unit 4	**Methods of data collection:** Concept of sampling and other concepts related to sampling. Probability and non-probability samples, their characteristics and implications. Tools of data collections, their types, attributes and uses. Redesigning, research tools-like questionnaire, opinionnaire, observation, interviews, scales and tests etc. **Methods of data analysis:** Analysis of qualitative data based on various tools. Analysis of quantitative data and its presentation with tables, graphs etc. Statistical tools and techniques of data analysis-measures of central tendency, dispersion. Decision making with hypothesis testing through parametric and non-parametric tests. Validity and delimitations of research findings.
Unit 5	**Interpretation and Report Writing:** Meaning of Interpretation, Techniques of Interpretation, Significance of Report Writing, Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Writing a technical paper, plagiarism and its implications.

Text and Reference Books

1. Garg B. L., Karadia R., Agarwal F. and Agarwal U. K., An introduction to Research Methodology, RBSA Publishers, 2002
2. Kothari C. R., Research Methodology: Methods and Techniques. New Age International, 1990.
3. Merriam S. B., Tisdell E. J., Qualitative Research: A Guide to Design and Implementation, 4th edition, John Wiley & Sons, 2016.
4. Creswell J. W., Research Design: Qualitative, Quantitative and Mixed Methods Approaches, 4th edition, SAGE Publications, Inc, 2014.
5. Olsen C., Devore J., Peck R., Introduction to Statistics and Data Analysis, 5th edition, Brooks/Cole, 2015.
6. Panneerselvam R., Research Methodology, 2nd edition, PHI Learning, 2014.

Assessment: ISEI (Class Test), ISEII (TA) & ESE
TA: Students will perform one or more of the following activities

1. Surprise Test
2. Assignment
3. Quiz
4. Any other activity suggested by course coordinator

Assessment Pattern

Assessment Pattern Level No.	Knowledge Level	ISE I	ISE II	End Semester Examination
K1	Remember	05	02	06
K2	Understand	10	08	24
K3	Apply	00	03	09
K4	Analyze	05	04	12
K5	Evaluate	00	03	09
K6	Create	00	00	00
Total		20	20	60

Mapping of Course Outcomes with Program Outcomes:

Outcomes	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3		
CO2	2	2	2		
CO3	2		3	1	
CO4	1		3	1	
CO5	1	3	2		2

1 – Low, 2 – Medium, 3 – High

INCCC5001: Yoga / Club Activities		
Teaching Scheme	**Examination Scheme**	
Practicals: 02 Hrs. / Week	**Audit Course**	
Credits: 00		

Course D**escription**: Co-curricular activities are activities that take place outside of a course's curriculum but are related to academics in some way. Although involvement is not part of classroom instruction, it does supplement and enhance a student's academic experience.

Yoga - In today's stressful life, there is much more need to experience relaxation and remain focused. The inner connect is very much needed to retain stability. Beyond physical exercise there is much more to do in the field of Yoga. The content of this course includes Yoga, Pranayam, Meditation, Relaxation, rejuvenation and connection with our own self. The introduction of such an experiential course helps to boost self-confidence and with regulation of mind through meditation improves concentration. Meditation is basically training of mind and helps to regulate it. Along with experiential learning, the students are also exposed to learnings contained in the supported literature.

The student shall perform: a) Perfection in at least 3 types of Yoga-asanas (Trikonasan, Konasan and Ustrasana) b) Perfection in at least 3 types of Pranayama (Anulom-Vilom, Bhramari and Kapalbhati) c) Regular practice of Yoga-asanas, Pranayam and Meditation for 10 minutes during the allotted periods as per the time table and daily at home.

The evaluation is based on participating and performing Yoga, Pranayam and meditation regularly and perfectly under the guidance of Yoga Teachers. Meditation trainers will observe intrinsic goodness, the right attitude and a happy and joyous way of doing things.

Club activities: Government Engineering College Chhatrapati Sambhaji Nagar has various clubs that focus on specific interests such as robotics, coding, literature, environment, etc. These clubs often organize events, workshops, and competitions that provide students with opportunities to learn new skills and showcase their talents. Students will participate in Club Activities throughout the semester. Faculty coordinators will coordinate along with student bodies the activities of the club.

The faculty coordinators will certify at the end of semester about participation of students.

Semester II

EEPCC5010: Power System Dynamics and Stability	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I Test : 20 Marks
Tutorial: 0 Hr/Week	ISE III, : 20 Marks
Credits: 03	End Sem Exam : 60 Marks

Course description: This is a compulsory course & covers different stability aspects of power systems.

Course Objectives: The objectives of the course are to:

1. Explain the basics of power system stability.
2. Explain different methods to determine the transient stability of power systems.
3. Acquaint the students with small signal stability of power systems.
4. Introduce the concepts of voltage stability.
5. Explain the methods of stability improvement.

Course Outcomes: After completing the course, students will able to:

CO 1	Describe stability conditions of power systems.
CO 2	Apply numerical methods to determine stability under various fault conditions.
CO 3	Explain the effect of excitation on small signal stability.
CO 4	Explain the concepts related to voltage stability.
CO 5	Describe various methods of stability enhancement.

Detailed Syllabus:

Unit 1	**Power System stability considerations:** definitions- classification of stability-rotor angle and voltage stability- synchronous machine representation- classical model-load modeling- concepts-modeling of excitation systems- modeling of prime movers.
Unit 2	**Transient stability:** Swing equation-equal area criterion-solution of swing equation-Numerical methods- Euler method-Runge-Kutta method-critical clearing time and angle-effect of excitation system and governors-Multi-machine stability-extended equal area criterion- transient energy function approach.
Unit 3	**Small signal stability:** State space representation – Eigenvalues- modal matrices-small signal stability of single machine infinite bus system – synchronous machine classical model representation-effect of field circuit dynamics-effect of excitation system-small signal stability of a multi machine system.
Unit 4	**Voltage stability**: Basic concepts related to voltage stability, voltage collapse, voltage stability analysis, prevention of voltage collapse
Unit 5	**Methods of improving stability:** Transient stability enhancement-high speed fault clearing-steam turbine fast valuing-high speed excitation systems- Fundamentals and performance of Power System Stabilizer-Multi band PSS-Three dimensional PSS-Location & dispatch of reactive power by VAR sources.

Text and Reference Books

1. P. M. Anderson and A.A. Fouad, *Power System Control and Stability*, IOWA state university press, USA
2. P.Kunder, *Power System stability and Control*, McGraw Hill, New York
3. P. Sauer and M.A. PAI, *Power system dynamics and stability*, Prentice Hall, 1997
4. K.R.Padiyar, *Power System Dynamics, Stability and Control*, Edition II Interline Publishers, Bangalore, 1996
5. Van Cutsem, T. and Vournas, C.,*Voltage Stability of Electric Power Systems*, Kluwer Academic Publishers, 1998.
6. Taylor.C.W, *Power System Voltage Stability*, McGraw-Hill, 1994.
7. P.S.R. Murty, *Power System Operation & control*, Tata McGraw Hill
8. Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., New York.

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		10
K2	Understand	10	10	25
K3	Apply	5	10	25
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K1+K2+K3	K2+K3	K2+K3	K2+K3	K2+K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)		5	5	5	5
ESE Assessment (60 Marks)	12	12	12	12	12

EEPCC5011: HVDC and FACTS	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits: 03	ESE : 60 Marks

Course Objectives:

The objectives of the course are to-

1. Understand the configuration and working of HVDC systems
2. Analyze harmonics and to understand the different protection schemes of HVDC systems
3. Understand operating principle of FACTS devices
4. Analyze the operation of shunt, series and combined compensators
5. Impart knowledge on application of shunt, series and combined compensator to improve AC transmission.

Course Outcomes: After completing the course, students will able to:

CO1	Review the HVDC transmission systems, design the HVDC converters
CO2	Identify the suitable methods to review and reduce the harmonics in HVDC system
CO3	Analyze the reactive power compensation in AC transmission systems
CO4	Analyze suitable compensation for AC transmission systems
CO5	Apply the concepts to electrical power transmission systems

Detailed Syllabus:

Unit-1	**Introduction:** Comparison of AC and DC transmission systems, application of DC transmission, types of DC links, layout of a HVDC converter station. HVDC converters, pulse number, analysis of Graetz circuit with and without overlap, converter bridge characteristics, equivalent circuits or rectifier and inverter configurations of twelve pulse converters
Unit-2	**Converter & HVDC System Control:** Principles of DC Link Control — Converters Control Characteristics — system control hierarchy, firing angle control, current and extinction angle control, starting and stopping of DC link.
Unit-3	**Harmonics, Filters and Reactive Power Control:** Introduction, generation of harmonics, AC and DC filters. Reactive Power Requirements in steady state, sources of reactive power, static VAR systems. **Power Flow Analysis in AC/DC Systems:** Modeling of DC/AC converters, Controller Equations-Solutions of AC/DC load flow —Simultaneous method-Sequential method.
Unit-4	**Introduction to FACTS:** Flow of power in AC parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers. **Static Shunt Compensators:** Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM.

Unit-5	**Static Series Compensators**: Objectives of series compensation, variable impedance type-thruster switched series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC)-power angle characteristics-basic operating control schemes. **Combined Compensators:** Introduction, unified power flow controller (UPFC), basic operating principle, independent real and reactive power flow controller, control structure.

Text Books:

1. HVDC Transmission, S. Kamakshaiah, V. Kamaraju, The Mc-Graw Hill
2. HVDC power Transmission systems by K.R. Padiyar, Wiley Eastern Limited
3. Understanding of FACTS by N.G. Hingorani & L. Gyugyi, IEEE Press.
4. Flexible AC Transmission Systems (FACTS) Young Huasong & Alian T. hons, The Institution of Electrical Engineers, IEEE Power and Energy Series 30.

ISE III Assessment:

Assessments will be based on any two following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test I**	**Teachers Assessment**	**End Semester Examination**
K1	Remember	05	04	15
K2	Understand	10	04	15
K3	Apply	05	08	20
K4	Analyze		04	10
K5	Evaluate		-	-
Total Marks: 100		**20**	**20**	**60**

Sample Assessment Table:

Assessment Tool	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3+K4**
	C01	C02	C03	CO4	CO5
ISE I (20 Marks)	5	5	5	5	-
ISE III (20 Marks)	4	4	4	4	4
ESE (60 Marks)	12	12	12	12	12

EEPCC5012 : Simulation Laboratory-II	
Teaching Scheme	**Examination Scheme**
Practical: 04 Hrs/Week	Term Work : 25 Marks
Credits: 02	Viva-voce : 25 Marks
	Total : 50 Marks

Term Work Shall consist of record of minimum eight experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity

Part I

Any **10** experiments from the following list

1. Familiarization with MATLAB and basics of simulation and measurement
2. Coding to write the equations, loop operations, conditional operations and draw the plots (self-study).
3. Measurement of RMS and Average value of voltage and current, calculation of power factor, and calculation of active and reactive power in Simulink, using basic blocks of MATLAB/Simulink.
4. Generation of angular positions with respect to the sensed current/voltage and measurement of frequency of the sensed signal, and power factor in Simulink simulation, for the case of a transmission line fed by an ac supply and feeding resistive/inductive/capacitive load one at a time.
5. Use of lookup table approach to calculate i. The firing angle from the required value of impedance for cases of variable impedance-based FACTs Controller. 34 ii. generate sinusoidal reference from the generated/calculated angular positions from the sensed voltage/current
6. Simulink block set for Power Electronics and Power System Components. Simulation of the basic power electronics converter topologies, such as single-phase half wave rectifier, ac voltage controller, and inverter.
7. Sizing, simulation and operation of TCSC for a transmission line fed by an ac supply and feeding resistive/inductive/capacitive load one at a time. a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: all the modes of operation are required to be demonstrated
8. Sizing, simulation and operation of STATCOM for a transmission line fed by an ac supply and feeding a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: Four quadrant operations is required to be demonstrated
9. Sizing, simulation and operation of SSSC for a transmission line fed by an ac supply and feeding a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: Four quadrant operations is required to be demonstrated.
10. Harmonic analysis of non-linear loads using Power analyzer and its mitigation using passive filters
11. Study of ATP, PSCAD and MATLAB (Simulink)software
12. Simulation of various faults in power system
13. Simulation of AVR, PSS models
14. Study of Transient over voltages
15. Stability studies – i) Large/small signal rotor angle stability ii) voltage instability.
16. PID controller-Design and implementation for close loop operation of electrical drives

Part- II

1. Study, simulation and presentation of IEEE Transaction papers on FACTs devices related applications. (Each student has to select different paper)
2. Study, simulation and presentation of IEEE Transaction papers on Power Systems dynamics and stability related topics. (Each student has to select different paper)
3. Study, simulation and presentation of IEEE Transaction papers on topics from (Elective III, IV and V courses) related applications or topics. (Each student has to select different paper)

EEPCC5013: Lab Renewable Energy Technology	
Teaching Scheme Practical : 02 Hrs/Week Credits : 01	**Examination Scheme** Term Work : 25 Marks Total : 25 Marks

Term Work shall consist of a record of minimum twelve experiments/assignments using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity.

Following is the list of experiments is just a guideline (Hardware and Software base)

1. Plot I-V and P-V characteristics of single Solar PV Module with radiation and temperature changing effects
2. Plot I-V and P-V characteristics with series and parallel combination of Solar PV modules.
3. Study effect of shading on output power of Solar PV Module
4. Measure output power of solar PV system with effect of tilt angle
5. Plot charging and discharging characteristics of battery
6. Measure performance parameters of DC load system with and without battery (with variable rated capacity system) in Solar PV stand-alone system.
7. Measure performance parameters of AC load system with and without battery in Solar stand-alone PV system.
8. Measure performance parameters of Combine AC and DC load system with and without battery in Solar stand-alone PV system.
9. Study of biomass plant
10. Identify and measure the parameters of a solar PV Module at Specific location
11. Measure the spectral response of a solar cell and Calculate quantum efficiency
12. Study solar resource assessment station and record associated parameters
13. Simulate characteristics of fuel cell using electrical software
14. Simulate operation of wind turbine and measure associated parameters using electrical software
15. Study of Tri-brid system

List of Program Electives III, IV and V in Semester II

EEPEC5011: Electrical Power Distribution Systems	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description: This is the course in Electrical Engineering which introduces the basic concepts and techniques for processing signals on a computer and being familiar with filter design, transform-domain processing and importance of Signal Processors.

Course Objectives: The objectives of the course are to give exposure to-

1. Distinguish between transmission, and distribution line and design the feeders
1. Design of distribution feeders and select appropriate substation location
3. Compute power loss and voltage drop of the feeders
4. Design protection of distribution systems
5. Understand the importance of voltage control and power factor improvement

Course Outcomes:

After completing the course, students will able to:

CO1	Understand the general concepts of distribution systems and difference between transmission systems and distribution systems
CO2	Design the distribution feeders and secondary distribution system and Identify and select appropriate sub–station location
CO3	Analyze a distribution system for voltage drop and power loss calculation
CO4	Understand faults on distribution systems and protective devices and its coordination for protection of distribution systems.
CO5	Analyze Voltage control and Power factor improvement procedures for distribution systems.

Detailed Syllabus:

Unit I	**Introduction and General concepts** Introduction to Distribution Systems: Load modeling and Characteristics- Coincidence factor, Contribution factor, loss factor, Relationship between the load factor and loss factor – Classification and characteristics of loads -Residential, commercial, Agricultural and Industrial. Distribution System Planning
Unit II	**Distribution Feeders and Substations** **Distribution Feeders:** Design Considerations of distribution feeders: Radial, loop and network types of primary feeders – Voltage levels, – Feeder loading, general circuit constants (A, B, C, D) to radial feeders, Distribution Sub–Stations: Distribution substations –Bus schemes –comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels
Unit III	**Distribution System Analysis:** **Voltage drop and power–loss calculations**: Derivation for voltage drop and power loss in lines-Uniformly distributed loads and non-uniformly distributed loads -Numerical problems-Three phase balanced primary lines. Power Flow Analysis of balanced distribution system Distributed Generation in Distribution System: Need for Distributed generation, renewable sources in distributed generation, Power flow analysis with DGs, Concept of micro-grid
Unit IV	**Protective Devices & Coordination:** Objectives of Distribution system protection, Types of common faults and procedure for fault calculation **Protective devices:** Principle of operation of fuses, circuit reclosers and line sectionalizers and circuit breakers. **Coordination of Protective device**s: General coordination procedure
Unit V	**Voltage control in Distribution systems** Voltage Control in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location. Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement.

Text Books and Reference Books

1. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers.
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4th edition, 1997.
3. Distribution System Modeling and Analysis by William H Kersting- CRC Press,Taylor and Francis Group 4th Edition, 2017
4. Turan Gonen, Electric Power Distribution System Engineering, CRC Press, 3rd Edition 2014.

ISE III Assessment: It is of 10 marks based on one of the / or combination of few of following,

1. Assignment , 2. MCQ

Sample Assessment Pattern:

Level No.	**Knowledge Level**	**ISE I**	**ISE II**	**ISE III**	**End Semester Examination**
K1	Remember	05			10
K2	Understand	10		10	25
K3	Apply	05		10	25
K4	Analyze				
Total Marks 100		20		20	60

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+k3+K4	K2+k3+K4
	C01	C02	C03	CO4	CO5
ISE I (20 Marks)	05	05	10		
ISE III (10 Marks)				05	05
ESE (60 Marks)	12	12	12	12	12

Special Instructions If Any: NIL

Designed by
Dr. Sunanda Ghanegaonkar

EEPEC5012 : Restructured Power Systems	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 3	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End-Semester Examination : 60 Marks

Course Description: This is an elective course & covers the different aspects of power systems in restructured the environment.

Course Objectives:

The objectives of the course are to learn:

1. Basic aspects of power system restructuring.
2. Different models of deregulated power systems.
3. Different methods to determine transmission pricing.
4. Available transfer capability.
5. Regulatory issues involved in the deregulation of the power industry.

Course Outcomes: After completing the course, students will able to:

CO1	Explain basic aspects of power system restructuring.
CO2	Explain different models of deregulated power systems.
CO3	Explain different methods to determine transmission pricing.
CO4	Determine available transfer capability.
CO5	Explain Ancillary Services management in various markets & regulatory issues.

Detailed Syllabus:

Unit 1	**Introduction:** Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.
Unit 2	**Deregulation of Power Sector:** Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services.
Unit 3	**Transmission Pricing:** Marginal pricing of Electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract Path method, Boundary flow method, MW-mile method, MVA-mile method, Comparison of different methods.
Unit 4	**Congestion Management:** Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Different Experiences in deregulation: England and Wales, Norway, China, California, New Zealand and Indian power system.

Unit 5	**Ancillary Services and System Security in Deregulation:** Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry.

Text and Reference Books

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd.
2. "Restructured power systems, operation, trading and volatility, "Mohammad shahidehpour, M.alomoush, CRC Press

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		10
K2	Understand	10	10	25
K3	Apply	5	10	25
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K1+K2	K2+K3	K2+K3	K2+K3	K2+K3
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)			5	5	10
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by Dr. V. A. Kulkarni

EEPEC5013: Integration of Renewable Energy Sources	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I Test : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description:

This course is a one-semester course which introduces different renewable energy sources & their integration with grid for first year M. Tech students

Course Objective:

The objectives of the course are to introduce and learn

1. Different types of renewable energy sources
2. Various solar PV technologies and its characteristics
3. Various solar thermal technologies and its applications
4. Wind energy technologies and its operations
5. Grid integration of wind energy systems and its associated issues

Course Outcomes: After completing the course, students will be able to:

CO1	Understand different renewable energy sources and storage devices
CO2	Explain various solar PV technologies and its characteristics
CO3	Describe various solar thermal technologies and its uses in various applications
CO4	Discuss wind energy technologies and explain its operations
CO5	Analyze and simulate control strategies for grid connected and off-grid systems

Detailed Syllabus:

Unit 1	**Introduction:** Electric grid, Utility ideal features, Hubert peak, Energy Scenario in India, Environmental impact of fossil fuels, Different types of energy sources - solar, wind, tidal, geothermal, wave energy
Unit 2	**Dynamic Energy Conversion Technologies:** Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of hydro and wind based generation technologies. types of wind turbines, power in the wind, Betz limit, Tip speed ratio, stall and pitch control, wind speed statistics, probability distribution, wind generator topologies, voltage and reactive power control, power quality standard for wind turbines
Unit 3	**Static Energy Conversion Technologies:** Principle of operation and analysis of fuel cell, photovoltaic systems and generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies -batteries, fly wheels,ultra & super capacitors . Design of stand-alone systems, Amorphous mono-crystalline, poly-crystallin & Thin film solar cell, Introduction to organic Solar PV Cell
Unit 4	**Solar Thermal Technology:** Solar Spectrum, Solar Geometry, Sun Earth angles, Solar radiation at given locations, Flat plate collector, Parabolic trough, Central receiver, parabolic dish, Fresnel, solar pond & solar still

Unit 5	**Grid Integration of Energy** Introduction & importance, sizing, Grid connected Photovoltaic systems classifications, operation, merits & demerits; operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC standards for renewable, energy grid integrations.

Text and Reference Books

1. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and sons,2004,ISBN 0-471-28060-7.
2. S. P. Sukhatme, "Solar Energy", Tata McGrew Hill, second edition, 1996, ISBN 0-07-462453-9
3. ChetanSingh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI-second edition
4 S. Chowdhury, S. P. Chowdhury, PCrossley "Microgrids and Active Distribution Networks", IET Power Electronics Series, 2012.
5. Ali Keyhani Mohammad Marwali and Min Dai "Integration and Control of Renewable Energy in Electric Power System"John Wiley publishing company, 2010, 2nd Edition.
6. John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", WileyIntersciencePublication, 1991
7.Report on "Large Scale Grid Integration of Renewable Energy Sources - Way Forward" Central Electricity Authority, GoI, 2013.
8. Siegfried Heier, "Grid integration of wind energy conversion systems" John Willy andsons ltd, 2006

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.
1.Presentation on latest topics/Real life problems related with the subject, 2. Simulations problems, 3. Quiz, 4. MCQ

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember			10
K2	Understand	10	10	20
K3	Apply	10	10	20
K4	Analyze			10
K5	Evaluate			
Total Marks 100		20	20	60

Assessment table:

Assessment Tool	K2+K3	K2+K3	K1+K2+K3	K2+K3	K2+K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	10			
Teachers Assessment (20 Marks)		5	5	5	5
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Dr. S. M. Shinde

EEPEC5014: Life Estimation of Power System Equipment			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 0 Hr/Week	ISE III	: 20 Marks
Total Credits	: 3	End -Semester Exam	: 60 Marks

Course description: This course introduces the various aspects for estimating the residual life of power system equipment**.**

Course objectives: -The objectives of the course are to

1 Introduce to Dielectric behavior of electric field
2. Introduce to insulation failure
3. Introduce to diagnostic techniques
4. Introduce to reliability assessment

.**Unit wise Course Outcomes expected:**

Students will be able to

CO1. Analyze the dielectric behavior of electric field
CO2. Understand the insulation failure
CO3. Diagnose in high voltage
CO4. Diagnose the faults in power system equipment
CO5. Assess the reliability of power system equipment

Detailed Syllabus:

Unit-I	**Dielectric behavior in electric and thermal fields:** Introduction, Mechanism of electrical conduction in matter, Charge storage in dielectric, Non-ideal dielectrics, Behavior of dielectric in time varying fields, Conduction in dielectrics, breakdown in dielectrics Measurement of dielectric parameter: General, Permittivity and Tan δ, Volume and surface conductivity, Partial discharge measurements, Calibration of PD Measuring circuit and detector, Measurement of dielectric strength
Unit-II	**Models for electrical insulation failure:** General, Physical models for insulation failure, single stress modeling, Multifactor models. Stochastic nature of electrical insulation failure: General, Statistical aspects of thermal ageing.
Unit-III	**Concepts in life testing of insulation:** General, Life testing strategies, Miner's theory of cumulative damage, Accelerated stress testing, Censored life testing (CLT).
Unit-IV	**Diagnostic testing of insulation in high voltage equipment:** General, Concepts in diagnostic testing, Endpoint criteria, Relevance of diagnostic tests and evaluation of test results.

Unit-V	**Equipment specific diagnostic and reliability assessment:** General, Types of insulation systems in power equipment, Equipment specific condition monitoring and diagnostic testing, Dry type systems, Gas insulated substations, Liquid impregnated and liquid filled systems.

Text books:

1. Reliability and life estimation of power equipment by T.S. Ramu & Chakradhar Reddy "New age international publishers"

Teaching Strategies:

The teaching strategy is planned through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.
ISE III Assessment: Teacher's Assessment based on assignments

Assessment table:

Assessment Tool	K1+K2	K2+K3	K2+K3	K2+K3	K2+K3
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I 20 Marks	10	10			
ISE III 20 Marks			05	05	10
ESE Assessment 60 Marks	12	12	12	12	12

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	10		20
K2	Understand	10	05	40
K3	Apply		10	
K4	Analyze		05	
K5	Evaluate			
K6	Create			
Total		20	20	60

EEPEC5015 : Optimization Techniques	
Teaching Scheme Lectures: 03 Hrs/Week Tutorial : 0 Hrs/Week Credits : 3	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End Semester Exam : 60 Marks

Course Description: Electrical Power Systems is growing at a faster pace. An Electrical Engineer should be able to solve the optimization problems in electrical engineering. This course is aimed to cover the fundamentals of LPP and NLPP optimization techniques for solving engineering problems.

Course Objectives: The objectives of the course are to

1. Introduce the fundamental concepts of Optimization Techniques;
2. Make the learners aware of the importance of optimizations in real scenarios;
3. Provide the concepts of various classical and modern methods for constrained and unconstrained problems in both single and multivariable.

Course Outcomes: After completing the course, students will able to:

CO1	formulate optimization problems
CO2	understand and apply the concept of optimality criteria for various type of optimization problems
CO3	solve various constrained and unconstrained problems in single variable as well as multivariable
CO4	apply the methods of optimization genetic algorithm for real life situation
CO5	apply the methods of optimization techniques for the application in power system engineering

Detailed Syllabus:

Unit 1	**Introduction:** Concept of optimization and classification of optimization techniques, formation of optimization problems Linear Programming : Standard form of LPP Simplex Method of solving LPP, duality in LP, transportation problem
Unit 2	**Non-Linear Problem (NLP) :** One dimensional methods: Elimination methods, Interpolation methods, Unconstrained optimization techniques:-Direct search and gradient based methods, Constrained optimization techniques:-Lagrange multiplier method, Kuhn-Tucker Conditions, Cutting plane Method, penalty function Methods
Unit 3	**Dynamic Programming:** Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem.
Unit 4	**Advanced Optimization Techniques:** Introduction to Multi objective Optimization, Swarm intelligences, Genetic Algorithm, and other Non-traditional Optimization Algorithms applications.
Unit 5	**Applications to Power system:** Applications of optimization techniques such as Economic Load Dispatch in thermal and Hydro-thermal systems, Unit commitment problem, reactive power optimization. Optimal power flow,

Text and Reference Books

Text book :

1. S.S.Rao, "Optimization - Theory and Applications", Wiley-Eastern Limited.
1. David G. Luenberger, "Introduction of Linear and Nonlinear Programming ", Wesley Publishing Company
2. Polak, "Computational methods in Optimization", Academic Press. Pierre D.A, "Optimization Theory with Applications", Wiley Publications.
4. Kalyanmoy deb, "Optimization for Engineering Design: Algorithms and Examples", Kalyanmoy deb, PHI Publication.
5. D.E. Goldberg & Addision, "Genetic Algorithm in Search Optimization and Machine Learning ", Wesley Publication, 1989
6. L.P. Singh, "Advanced Power System Analysis and Dynamics", Wiley Eastern Limited.
7. Hadi Saadat "Power System Analysis ", TMH Publication.
8. Olle I. Elgerd " Electrical Energy System : An Introduction", TMH Publication, New Delhi.

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5	10	10
K2	Understand	10	10	20
K3	Apply	5		30
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

Sample Assessment table :

Assessment Tool	K1+K2+ K3	K1+K2+ K3	K1+ K2	K2	K1+K3
	CO1	CO2	CO3	CO4	CO5
Class Test (20 Marks)	10	5	5		
Teachers Assessment (20 Marks)				10	10
ESE Assessment (60 Marks)	10	20	10	10	10

Teaching Strategies: The teaching strategy is planned through the lectures, tutorials and team based home Assignments.

Designed by Dr. S. P. Ghanegaonkar

EEPEC5016: Smart Appliances & IoT	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 20 Marks
Tutorial : 00	ISE III : 20 Marks
Total Credits : 03	End -Semester Exam : 60 Marks

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

CO1	Understand and evaluate the characteristics of smart home appliances.
CO2	Understand the behavior of IoT and their applications
CO3	Manage smart communication systems with multiple sensors and protocols
CO4	Design and simulate smart homes and smart cities with IoTs and cloud computing
CO5	Understand the behavior of IoT applications agriculture, Industrial applications etc

Unit 1	**Modern Domestic Appliances:** Solid State Lamps: Introduction - Review of Light sources - white light generation techniques- Characterization of LEDs for illumination application.
Unit 2	**Power LEDs:** High brightness LEDs- Electrical and optical properties. LED driver considerations-Power management topologies - color issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.
Unit 3	**IoT Communication Technologies:** Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT.
Unit 4	**IoT Control Technologies and Programming:** Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Internet of Things Open-Source Systems. Introduction to Python programming, Introduction to Raspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security.
Unit 5	**IoT Cloud Computation and Applications:** Introduction to SDN. SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor- Cloud. Fog Computing, Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring, Role of ML and AI in IoT.

Text / Reference Books:

1. Fundamentals of Solid-State Lighting, Vinod Kumar Khanna, CRC press, 2014.
2. Permanent Magnet Brushless DC Motor Drives and Controls, Chang-liang Xia, John Wiley & Sons Singapore Pte. Ltd., 2012, 1st Edition.
3. IoT for Smart Grids Design Challenges and Paradigms, K. Siozios, D. Anagnostos, D. Soudris, E. Kosmatopoulos, Springer, 2019, 1st Edition.

4. Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications,
Craig Di Louie, Fairmont Press, Inc., 2006, 1st Edition.
5.Lighting Control: Technology and Applications, Robert S Simpson, Focal Press, 2003, 1st Edition.
6. Introduction to solid state lighting, Arturas Zukauskus, Michael S. Shur & Remis Gaska, Wiley- Interscience, 2002, 1st Edition.
7. Power Electronics: Converters, Applications and Design, Mohan, Undeland and Robbins, John Wiley and Sons, 1989, 1st Edition.
Online Resources: www.aboutlightingcontrols.org.

EEPEC5017: Power Quality and Mitigation			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 00	ISE III	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Power Electronics, Electrical Machines, Power System

Course Description:

This course gives an introduction on power quality causes and effects, requirement of power quality improvements and mitigation aspects of power quality problems .

Course Objectives: The objectives of the course are to

1. Understand power quality problem and classify power quality events
2. Understand different methods of monitoring power quality and standards for power quality
3. Outline concept of Passive shunt and series compensators
4. Understand Active Shunt And Series Compensators
5. Understand Unified Power Quality Compensators

Course Outcomes: After completing the course, students will able to

CO1.	Identify and describe Power quality problems and classify power quality events.
CO2	Evaluate power quality indices in distribution system
CO3	Develop mitigation techniques for compensating devices to improve power quality in distribution systems
CO4	Suggest compensating devices to improve power quality in distribution system
CO5	Analyze Unified Power Quality Compensators

Detailed syllabus:

Unit-I	**Power Quality:** Significance of power quality, Power quality terms: Transients, Long-duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuation, CBEMA and ITI curves. Devices for Overvoltage Protection: Surge arresters and transient voltage surge suppressors, Isolation transformers and Low-impedance power conditioners. **Waveform Distortion:** Introduction, Voltage versus current distortion, Harmonics versus transients, Harmonics indices: Total Harmonics Distortion (THD) and Total Demand distortion (TDD); Harmonic standards; Harmonic analysis; Harmonic phase sequence; Triplen harmonics; Inter harmonics.
Unit-II	**Harmonic Sources:** Introduction; Harmonics generated from electrical machines such as transformers and rotating machines; Arcing devices; Static power conversion: Phase controlled and uncontrolled rectifiers, AC voltage regulators, Cycloconverters, Pulse width modulated inverters; Converter fed ac and dc drives

Unit-III	**Effects of Harmonic Distortion:** Introduction; Resonances; Effects of harmonics on rotating machines; Effect of harmonics on static power plant; Power assessment with distorted waveforms; Effect of harmonics on measuring instruments; Harmonic interference with ripple control systems; Harmonic interference with power system protection; Effect of harmonics on consumer equipment; Interference with communication systems
Unit-IV	**Harmonic Elimination:** Introduction; Passive power filters: Design, A Shunt active power filters: Configurations, State of the art, Design and control strategies. Three-phase four-wire shunt active power filters
Unit-V	**Voltage Quality:** Introduction; Sources of Sags, Swell, Unbalance and Flicker; Voltage quality standards; Effects of sags, Swell, Unbalance and Flicker; Voltage sag magnitude due to fault; Voltage sag magnitude calculation based on influence of cross section of conductor, transformer and fault levels; Critical distance for a voltage sag magnitude; Causes of phase- angle jumps in voltage; Classification of voltage sags, voltage sag transformation due to transformers.

Text Books:

1. BhimSingh,Ambrish Chandra(2015) "power quality problem and mitigation techniques , wiley Publications (ISBN: 9781118922057)
2. C. Sankaran (2002)" "Power Quality"CRC Press Publication.
3. Math, H. J .Bollen, "Understanding power quality problem", Standard Publication.
4. Roger C. Dugan, "Electrical power system quality"2nd edition, Mcgraw-Hill Publication.
5. Mohammed A.S.Masoum ,EwaldF.Fuchs" Power Quality in power systems and electric machines",2nd Edition,kindle edition,(ISBN: 978-0123695369)

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1 to K6	K1 to K6	K1 to K6	K1 to K6
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 20 Marks	5	5	10		
Teachers Assessment 20 Marks	4	4	4	4	4
ESE Assessment 60 Marks	12	12	12	12	12

ISE III Assessment: Teacher's Assessment is based on one of the /or combinations of the few of the following.

1) Home Assignments
2) Powerpoint presentation
3) Develop working models
4) Surprise written Test with multiple choice questions
5) Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	5	4	12
K2	Understand	10	4	12
K3	Apply	5	4	12
K4	Analyze		4	12
K5	Evaluate		4	06
K6	Create			06
Total		20	20	60

Designed by

Dr. N. J. Phadkule

EEPCC6011: Advanced Control System	
Teaching Scheme	**Examination Scheme**
Lectures: 03 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hrs /Week	ISE III : 20 Marks
Credits: 03	End Semester Exam : 60 Marks

Course Description:

This course is course of three credits. It introduces the various state feedback, nonlinear and digital control systems which will be helpful for understanding its applications in drives, and power systems.

Course Objectives:

The objectives of the course are to-

1. Explain the system representation in state space and design of state feedback
2. Explain the basics for design of robust control system
3. Explain the stability analysis of nonlinear control systems
4. Explain the representation of optimal control systems
5. Explain the applications industrial controllers
6. Explain the multi loop control systems

Course Outcomes: After completing the course, students will able to:

CO1	Apply systems in state space model
CO2	Design control system state feedback
CO3	Analyze the stability of nonlinear control systems
CO4	Formulate and represent the systems in standard form of optimal control
CO5	Apply industrial control for system and realize multi loop control system

Unit-1	**State feedback control system:** Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, physical systems and state assignment concept of controllability & observability, Lag and Lead compensator design.
Unit-2	**Control Design:** State feedback controller by pole placement and design of observer for linear systems, Design of PI/PID controller
Unit-3	**Nonlinear Control system:** Introduction to nonlinear systems, phase plane and describing function methods for analysis of linear systems and linearization using Describing function analysis, phase plane analysis, bang-bang control system, Lyapunov's stability analysis, Digital Control System: Discrete time systems, discretization, sampling, aliasing, choice of sampling frequency, ZOH equivalent
Unit-4	**Optimal Control System:** Introduction to optimal control system, problems, Quadratic performance index, Formulation of optimal control problem, linear quadratic regulator (LQR), Introduction to Adaptive control
Unit-5	**Process control system:** Introduction to process control, various control configurations such as: feed forward, cascaded etc. PID controller and implementation.

Text books/References

1. S. Sastry and M. Bodson, "Adaptive Control: Stability, Convergence, and Robustness", Prentice-Hall, 1989.
2. Gopal. M., "Control Systems: Principles and Design", Tata McGraw-Hill, 1997.
3. Kuo, B.C., "Automatic Control System", Prentice Hall, sixth edition, 1993.
4. Ogata, K., "Modern Control Engineering", Prentice Hall, second edition, 1991.
5. Nagrath Gopal, "Modern Control Engineering", New Age International

ISE III Assessments:

Assessments will be based on following:

1. Assignment 10 Marks
2. MCQ 10 Marks

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment**	**End Semester Examination**
K1	Remember	05	-	12
K2	Understand	10	10	36
K3	Apply	05	10	12
K4	Analyze	-	-	-
K5	Evaluate	-	-	-
K6	Create	-	-	-
Total Marks: 100		**20**	**20**	**60**

Sample Assessment Table:

Assessment Tool	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3+K4**
	C01	C02	C03	CO4	CO5
Class Test (20 Marks)	10	10	-	-	-
Teachers Assessment (20 Marks)	4	4	4	4	4
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by

Dr. S. S. Kulkarni

EEPCC6012: Advanced Electric Drives	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 20 Marks
Tutorial : 0 Hrs/Week	ISE III : 20 Marks
Credits **:** 03	End Semester Exam : 60 Marks

Course Description:
Advanced Electrical Drives is a one-semester course. It is an advanced course related to **Electric Drives**.
Course Objectives: The objectives of the course are to-
The objective of the course is to give exposure to the students of -
1. Fundamental of electrical drives.
2. Control & operation of AC & DC drives.
Course Outcomes:
After completing the course, students will able to:

CO1	Describe the fundamentals of electrical drives and solve numerical on it
CO2	Discuss and analyze performance of DC motor drives. Explain and analyze controlled rectifier fed and chopper fed dc drives
CO3	Implement Vector control for induction motor and the Direct Torque Control for Induction Motor Drives Implement slip power recovery schemes for induction motor drives and analyze 5-Ph IM drives
CO4	Analyze Permanent Magnet Drives
CO5	Analyze the SRM drives

Detailed Syllabus:

Unit-1	**Fundamentals of Electrical Drives:** Concept of electrical drives, Fundamental torque equation, Speed Torque conventions & multi-quadrant operation, Equivalent value of drive parameters, Components of load torque, Nature & classification of load torque, Calculation of time and energy-loss in transient operations, Steady state stability, Load equalization Modes of operation, Closed loop control, Selection of motor power rating
Unit-2	**DC Motor Drives:** DC motor and their performance, Starting, Braking- Regenerative, Dynamic and Plugging, Transient analysis, Speed control, Transient analysis, Energy losses during transient operations Controlled rectifier circuits, 1-phase full and half controlled rectifier-control, 3-phase full and half controlled rectifier control, Multi quadrant operation of fully-controlled rectifier-fed DC motor, Chopper control of separately excited dc motor, Chopper control of series motor
Unit-3	Induction Motor drives: Principle of vector control of IM, Indirect vector control with feedback, Indirect vector control with feed-forward, Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation, Direct Torque Control of IM, control of wound rotor induction machine, introduction to five-phase induction motor drives

Unit-4	Permanent Magnet Drives: Expression for torque, Model of PMSM, Implementation of vector control for PMSM, BLDC drives
Unit-5	Switched Reluctance Motor Drives: Torque expression, converters for SRM drives, Control of SRM drives

Text Books:

1. Analysis of Electric Machinery & Drive systems, Paul C. Krause, Oleg W, Scott D. Sudhoff, IEEE Press, 2013, 3rd Edition.
2. Modern Power Electronics & AC Drives, B.K. Bose, Pearson Education India, 2015, 1st Edition.
3. Electric Motor Drives: Modeling, Analysis and Control, R. Krishnan, Pearson Education India, 2015, 1st Edition.

Reference Books:

1. High-power Converters and AC Drives, Bin-Wu, Wiley-Blackwell, 2017, 2nd Edition.
2. Simulation of Power Electronic Circuits, M.B. Patil, V. Ramanarayanan, V.T. Ranganathan, Narosa Publications, 2013.

Online Resources:

1. nptel.ac.in/courses/108/104/108104140/
2. nptel.ac.in/courses/108/104/108104011/

ISE III Assessment:

Assessments will be based on any one or two of the following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment**	**End Semester Examination**
K1	Remember	05	04	15
K2	Understand	10	04	15
K3	Apply	05	08	20
K4	Analyze		04	10
K5	Evaluate		-	-
K6	Create		-	-
Total Marks: 100		**20**	**20**	**60**

Sample AssessmentTable:

Assessment Tool	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3**	**K1+K2+K3+ K4**
	C01	C02	C03	CO4	CO5
ISE I (20 Marks)	10	10	-	-	-
ISE III (20 Marks)	4	4	4	4	4
ESE (60 Marks)	12	12	12	12	12

Designed by
Prof. V.P.Dhote

EEPEC6013 : Energy Storage Systems			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 00	ISE III	: 20 Marks
Total Credits	: 3	End-Semester Exam	: 60 Marks

Course Description: Coverage of energy storage techniques involving electrochemical, mechanical and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design tradeoffs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage.

Course Objectives: The objectives of the course are to

1. Understand energy storage needs
2. Study and compare different methods of Electro-chemical energy storages
3. Understand superconducting magnetic energy storage systems
4. Get knowledge of mechanical and thermal energy storage systems
5. Study various energy storage applications and management of storage systems

Course Outcomes: After completing the course, students will able to

CO1.	Describe the need of energy storage systems - present and future
CO2	Demonstrate working/ operational principles of various Electrochemical Energy Storage systems
CO3	Explain superconducting magnetic energy storage systems
CO4	Explain mechanical energy storage and Thermal energy storage systems
CO5	Select appropriate energy storage systems for various applications and demonstrate management of energy storage systems

Detailed Syllabus:

Unit-I	**Necessity of Energy Storage:** Storage Needs-Variations in Energy Demand - Variations in Energy Supply-Interruptions in Energy Supply-Transmission Congestion-Demand for Portable Energy Demand and scale requirements, Environmental and sustainability issues, future prospect of storage
Unit-II	**Electrochemical Energy Storage:** Electrochemical storage system (11 Hours) (a) Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery & Metal hydride battery vs lead-acid battery. (b) Super capacitors- Working principle of super capacitor, types of super capacitors, cycling and performance characteristics, difference between battery and super capacitors, Introduction to Hybrid electrochemical super capacitors (c) Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-super capacitor systems

Unit-III	**Superconducting Magnetic Energy Storage:** Introduction to Superconducting Magnetic Energy Storage (SMES) operation, theory of usage and emergent research. Focus will primarily be on large utility scale energy storage facilities
Unit-IV	**Mechanical Energy Storage and Thermal Energy Storage:** Flywheel, Pumped hydro storage, compressed gas storage technologies, models for compressed gas capacity, efficiency and availability Thermal Energy Storage- Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems
Unit-V	**Applications:** Present status of applications, Utility use (Conventional power generation, Grid operation & Service), Consumer use (Uninterruptible power supply for large consumers), New trends in application, Renewable energy generation, Smart grid, Electric vehicles, Management and control hierarchy of storage systems, Internal configuration of battery storage systems, External connection of EES systems

Text and Reference Books:

1. Ter-Gazarian, A.G. (2011) *Energy Storage for Power Systems, 2nd Edition*, IET Publications (ISBN: 978-1849192194)
2. Huggins, R.A. (2010) *Energy Storage*, Springer, (ISBN: ISBN 978-1441910240)
3. R. P. Deshpande, "Ultracapacitors", McGraw Hill Education Publication.
4. Robert A. Huggins, "Energy Storage", Springer Publication.
5. Fransisco Diaz," Energy storage in power systems", published by Wiley.

Mapping of Course outcome with program outcomes:

Course outcome	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
CO1	3	2	1	1	1	1	1	1	1	1		1	1	1	1
CO2	3	2	2	1	1	1	1	1	1	1		1	1	1	1
CO3	3	2	1	1		1	1	1	1	1		1	1	1	1
CO4	3	2	1	1		1		1	1	1		1	1		
CO5	3	2	1	1		1	1	1	1	1		1	1	1	1

1- Low 2- Medium 3- High

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K1 to K6	K1 to K6
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I 20 Marks	10	10			
ISE III Assessment 10 Marks			05	05	10
ESE Assessment 60 Marks	12	12	12	12	12

ISE I , II are compulsory tests

ISE III Assessment: Teacher's Assessment is based on one of the following.

1. Assignments, 2. Models/ Presentations, 3. multiple choice questions test, 4. Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**		**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	5	5	2	10
K2	Understand	5	5	2	20
K3	Apply	5	5	3	20
K4	Analyze			3	10
Total		15	15	10	60

Designed by
Dr. Sunanda Ghanegaonkar

EEPEC6014: Machine Learning and Applications			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE	: 20 Marks
Tutorial	: 00	ISE III	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Course Outcomes (COs):

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

CO1	Understand basic concepts of Machine Learning Techniques
CO2	Distinguish between supervised learning, unsupervised learning and reinforced learning
CO3	Develop the skills in using machine learning software for solving practical problems
CO4	Apply Machine Learning Algorithms for Electrical Engineering problems

Detailed Syllabus:

Unit I	**Neural Networks:** Introduction to Neural Networks, Models of Neuron Network, Architectures – Knowledge representation, Artificial Intelligence and Neural Networks – Learning Process, Error Correction Learning, Multi-layer perceptron using Back Propagation Algorithm (BPA) Learning Theory**:** Introduction to Machine Learning: What is Learning – Learning Objectives – Data needed – Bayesian inference and Learning – Bayes theorem – inference – naïve Bayes – Regularization – Bias-Variance Decomposition and Trade-off – Concentration Inequalities – Generalization and Uniform Convergence – VC –dimension- Types of Learning- Supervised Learning – Unsupervised Learning and Reinforcement Learning
Unit II	**Supervised Learning:** Simple linear Regression – Multiple Linear Regression- Logistic Regression – Exponential Family and Generalized Linear Models- Generative Models: Gaussian Discriminant Analysis, Naïve Bayes – Kernel Method: Support Vector Machine (SVM) – Kernel function – Kernel SVM - Gaussian Process – Tree Ensembles: Decision Trees- Random Forests – Boosting and Gradient Boosting
Unit III	**Un Supervised Learning: (CLUSTERING):** K –means Clustering Algorithm – Gaussian Mixture Model (GMM) – Expectation Maximization (EM)-Variational AutoEncoder (VAE) – Factor Analysis – Principle Components Analysis (PCA) – Independent Component Analysis (ICA)
Unit IV	**Reinforcement Learning:** Markov Decision Processes (MDP)-Bellman's Equations- Value Iteration and Policy Iteration - Value Function Approximation - Q-Learning
Unit V	**Applications of ML:** Load Forecasting – Energy Market forecasting – Fault identification and localization – Renewable Uncertainty estimation

Text Books:

1. Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2011
2. Machine Learning, E. Alpaydin, MIT Press, 2010 Reference Books:
3. Machine Learning, Tom M. Mitchell, McGraw Hill International Edition, 1997
4. Online Resources: https://www.learndatasci.com/best-machine-learning-courses/

HSS AEC- I

EEAEC5001:(HSS- Technical Communication)	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I Test : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Outcomes (COs):

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

CO1	Understand the nature and objective of Technical Communication relevant for the workplace as Engineers.
CO2	Utilize the technical writing for the purposes of Technical Communication and its exposure in various dimensions
CO3	Imbibe inputs by presentation skills to enhance confidence in the face of diverse audience.
CO4	Evaluate their efficacy as fluent & efficient communicators by learning the voice-dynamics.

Detailed Syllabus:

Unit I	**Fundamentals of Technical Communication:** Technical Communication: Features; Distinction between General and Technical Communication; Language as a tool of Communication; Dimensions of Communication: Reading & comprehension; Technical writing: sentences; Paragraph; Technical style: Definition, types & Methods; The flow of Communication: Downward; upward, Lateral or Horizontal; Barriers to Communication.
Unit II	**Forms of Technical Communication:** Technical Report: Definition & importance; Thesis/Project writing: structure & importance; synopsis writing: Methods; Technical research Paper writing: Methods & style; Seminar & Conference paper writing; Key-Note Speech: Introduction & Summarization; Expert Technical Lecture: Theme clarity; Analysis & Findings; 7 Cs of effective business writing: concreteness, completeness, clarity, conciseness, courtesy, correctness, consideration.
Unit III	**Technical Presentation:** Strategies & Techniques Presentation: Forms; interpersonal Communication; Classroom presentation; style; method; Individual conferencing: essentials: Public Speaking: method; Techniques: Clarity of substance; emotion; Humour; Modes of Presentation; Overcoming Stage Fear: Confident speaking; Audience Analysis & retention of audience interest; Methods of Presentation: Interpersonal; Impersonal; Audience Participation: Quizzes & Interjections.

Unit IV	**Technical Communication Skills:** Interview skills; Group Discussion: Objective & Method; Seminar/Conferences Presentation skills: Focus; Content; Style; Argumentation skills: Devices: Analysis; Cohesion & Emphasis; Critical thinking; Nuances: Exposition narration & Description; effective business communication competence: Grammatical; Discourse competence: combination of expression & conclusion; Socio-linguistic competence: Strategic competence: Solution of communication problems with verbal and non verbal means.
Unit V	**Kinesics & Voice Dynamics: Kinesics:** Definitions; importance; Features of Body Language; Voice Modulation: Quality, Pitch; Rhythm; intonation; Pronunciation; Articulation; stress & accent; Linguistic features of voice control: Vowel & Consonant Sounds.

Text Books:

1. Technical Communication – Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press, 2007, New Delhi.
2. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd., 2001, New Delhi.
3. Practical Communication: Process and Practice by L.U.B. Pandey; A.I.T.B.S. Publications India Ltd.; Krishan Nagar, 2014, Delhi.
4. Modern Technical Writing by Sherman, Theodore A (et.al); Apprentice Hall; New Jersey; U.S.
5. A Text Book of Scientific and Technical Writing by S.D. Sharma; Vikas Publication, Delhi.
6. Skills for Effective Business Communication by Michael Murphy, Harvard University, U.S.
7. Business Communication for Managers by Payal Mehra, Pearson Publication, Delhi. Course Outcomes

Open Elective- I

EEOEC5001:(Open Elective -I) Introduction to Electric Vehicle	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I Test : 20 Marks
Tutorial: 0 Hr/Week	Teachers Assessment : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description:

This course is a one-semester course as a mandatory course. It is a course related to use of digital signal processing and other new technologies for power system protection.

Course Objective:

The objectives of the course are to introduce & explain:

1. To Understand the fundamental laws and vehicle mechanics.
2. To Understand working of Electric Vehicles and recent trends.
3. Ability to analyze different power converter topology used for electric vehicle application.
4. Ability to develop the electric propulsion unit and its control for application of electric vehicles.

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

CO1	Explain the roadway fundamentals, laws of motion, vehicle mechanics and propulsion system design.
CO2	Explain the working of electric vehicles and hybrid electric vehicles in recent trends.
CO3	Model batteries, Fuel cells, PEMFC and super capacitors.
CO4	Analyze DC and AC drive topologies used for electric vehicle application.
CO5	Develop the electric propulsion unit and its control for application of electric vehicles.

Detailed Syllabus:

Unit I	**Vehicle Mechanics:** Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle - Motion, Propulsion Power, Force-Velocity Characteristics, Maximum Gradability, Velocity and Acceleration, Constant tractive effort F_{TR}, Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Nonconstant F_{TR}.
Unit II	**Electric and Hybrid Electric Vehicles:** Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains.
Unit III	**Energy storage for EV and HEV:** Energy storage requirements, Battery parameters, Types of Batteries, Modeling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modeling of PEMFC, Supercapacitors.

Unit IV	**Electric Propulsion:** EV consideration, DC motor drives and speed control, Induction motor drives, BLDC and PMSM motor Drives, Switched Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives.
Unit V	**Design of Electric and Hybrid Electric Vehicles:** Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine generator, design of Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design.

Text Books & Reference Books:

1. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Husain, CRC Press 2003
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design by M. Ehsani, Y. Gao, S.Gay and Ali Emadi, CRC Press 2005
3. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer 2013
4. Modern Electric Vehicle Technology by C.C. Chan and K.T.Chau, OXFORD University 2001
5. Hybrid Electric Vehicles Principles And Applications With Practical Perspectives by Chris Mi, M. Abul Masrur, David Wenzhong Gao, Wiley Publication 2011

EEOEC5002 : Energy Audit & Management	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hrs/Week Credits : 03	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End-Semester Examination : 60 Marks

Course Objectives:

After completing the course, students will able to:

CO1	describe the concept of energy management and various regulations related to energy conservation
CO2	demonstrate the significance of energy audit
CO3	apply the different methods used for the economic analysis of energy projects
CO4	appraise the significance of energy efficient use of electricity
CO5	understand demand side management

Detailed Syllabus:

Unit 1	**Energy Scenario and Management:** An overview of Indian Energy Scenario, Sector Wise Energy Consumption in India, Energy needs of Growing Economy, Long Term Energy Scenario for India. Reasons to save energy (both financial and environmental), Energy Conservation and its importance, Energy Conservation Act and related policies, Bureau of Energy Efficiency (BEE)Regulations. Need to Manage Energy, Definition and objectives of Energy Management, Components of Energy Management program and their explanation.
Unit 2	**Energy Audit:** Energy audit concepts, Scope of energy audit, types of energy audit, general procedure for a detailed energy audit, various energy audit methodologies, instruments and metering for energy audit, general procedure for a detailed energy audit, preparation of detailed energy audit report, benefits of energy audit. Case study of energy audit in different industrial organizations / electrical utilities.
Unit 3	**Utility Rate Structures and Financial Analysis:** Understanding Energy Costs, Innovative rates – Time – of - Use rates, Real Time Pricing Rates, Financial Incentive Rates, Energy Purchase Rates. Basic concept of Economic Analysis–Interest Rate, Inflation rate, Single Payment, Uniform–Series Payment. Economic Evaluation Methods – Net Present Worth, Rate of Return, Benefit – Cost Ratio, Payback period. Comparison of Various Economic Evaluation Methods.
Unit 4	**Energy Efficiency in Electrical Systems:** Introduction,EnergyEfficientMotor,AdjustableSpeedDrives,EnergySavingCalculations, Energy Efficient Lighting Systems, High Efficiency Fluorescent Lamps, Compact Fluorescent Lamps, Cost Effectiveness of Efficient Lightning Technologies ,Automatic Power factor Controllers, HVAC system, Role of New Equipment and Technology in Industrial Energy Efficiency.
Unit 5	**Demand Side Management** Introduction to Demand Side Management, Integrated Resource Planning Concepts, Relation between Demand Side Management and Integrated Resource Planning, Demand Side Management Programs, Cost Benefit Analysis of Demand Side Management.

Text and Reference Books

1. Smith C.B. Energy Management Principles, PergamonPress,NewYork.
2. WayneC.Turner,SteveDoty,EnergyManagementHandbook,TaylorandFrancisLtd.,CRCPress.
3. FrankKreith,Goswami.Yogi,EnergyManagementandConservationHandbook,Taylorand Francis Ltd., CRC Press.
4. Albert Thumann, TerryNiehus, WilliamJ. Younger, Handbookof EnergyAudits,Taylor and Francis Ltd., CRC Press.
5. Rajive Shanker,EnergyAuditinginElectricalUtilities,VivaBookPvt.Limited,NewDelhi.
6. BureauofEnergyEfficiency,GeneralAspectsofEnergyManagementandEnergyAudit.New Delhi.

ISE III Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		10
K2	Understand	10	10	30
K3	Apply	5	10	20
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		20	20	60

EEEEM6002 : Engineering Economics	
Teaching Scheme Theory : 3 Hrs/Week Credits :3 Hrs/ week	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks ESE :60 Marks Total : 100 Marks

Students will be able to

1. Understand the nature of markets and competition
2. Learn about Basic Concepts of Economics, Micro and Macro
3. Understand the importance of how industries behave
4. Understand the basis in our day to day life to gain personal financial control
5. Know finance generation and funding

Detailed syllabus

Unit 1	**Basic Concepts of Economics:** Definitions, Overview of Micro and Macro Economics, Explanation of theories of demand, supply and market equilibrium and Economics Basics – Cost, efficiency and scarcity, Opportunity Cost
Unit 2	**Micro Economics:** Differences and Comparison, Theories of Utility and Consumers Choice, Competition and Market Structures, Markets and Prices, Market Failures, Income Distribution and Role of Government
Unit 3	**Macro Economics:** Aggregate Demand and Supply, Economic Growth and Business Cycles, The role of the Nation in economic activity, New Economic Policy in India, Fiscal Policy, GDP and Inflation, Consumption, savings and investments, Commercial and Central banking
Unit 4	**Industrial Economics** Behavior of firms: Strategies with regard to entry, pricing, advertising, and R & D and innovation. The development of Firms and Market and Industrial Structure: Stochastic models of firm growth, and market structure, inter-industry differences in growth rate variance, economies of scale, technical change, mergers and market concentration.
Unit 5	**Development of Competitive capabilities:** Role of Technology and Skills, FDI and Technology Transfer, Technological Spillovers, Globalization and Technology Intermediation.

Text books/Reference Books:

1. Baumol, William J., Economic Theory and Operations Analysis, [Prentice Hall India Ltd.] Fourth Edition, 1985.
2. Sloman, John H., Economics [Prentice Hall India Ltd.] Second Edition, 1994.
3. Varian, Hal, ` Intermediate Microeconomics: A Modern Approach, Fifth Edition
4. P.A. Samuelson & W.D. Nordhaus, Economics, McGraw Hill, New York, 1995. Koutsoyiannis, Modern Microeconomics, Macmillan, 1975.
5. R. Pindyck and D.L. Rubinfeld, Microeconomics, Macmillan Publishing Company, New York, 1989.
6. R.J. Gordon, Macroeconomics 4th Edition, Little Brown & Co., Boston, 1987.
7. William F. Shughart II, The Organization of Industry, Richard D. Irwin, Illinois, 1990. (Chapter 3).

INIKS6001 Vedic Approach to Mathematics		
Teaching: Scheme	**Examination Scheme**	
Lectures:02hrs/week	**ISEI**	**10 Marks**
Credits:2	**ISEII**	**10Marks**
	ESE	**30 Marks**

Course description: This course is planned as Ability enhancement course. It is an exposure to the Engineering students about Vedic Mathematics. Vedic Mathematics is a collection of Techniques/Sutras to solve mathematical arithmetic in easy and faster way. It consists of 16 Sutras (Formulae) and 13 sub-sutras (Sub Formulae) which can be used for problems involved in arithmetic, algebra, geometry, calculus, conics. By using Vedic Maths, the problems are solved mentally with the use of few or some of steps which increase accuracy and reduce mistakes. Through the application of the sutras, it ensures both speed and accuracy and enhances computational skills. In this course some of the topics from Vedic Mathematics are introduced which are use full to Engineering Students.

Course Objectives:

The main objectives of the course are:

1. Multiply two or three digits numbers.
2. Compute the division by two and three digit divisors.
3. Check the divisibility by two or three digit numbers without actual division.
4. Evaluate square, cubes, square roots and cube roots of larger numbers within no time.
5. To factorize the quadratic expressions of single variable.
6. To find the Solution of Linear Simultaneous Equations

Course Outcomes

After completing the course, students will be able to:

CO1	Do multiplication and division of two and three digit numbers by applying Sutras in Vedic Mathematics
CO2	To factorize and find LCM/HCF of numbers by applying Sutras in Vedic Mathematics
CO3	To solve Simultaneous Linear Equations by applying Sutras in Vedic Mathematics

Detailed Syllabus:

Unit 1	**Multiplication :** 1. Ekadhikenpurven method (multiplication of two numbers of two digits) 2. Eknunenpurven method (multiplication of two numbers of three digits) 3. Urdhvatiragbhyam method (multiplication of two numbers of three digits) 4. Nikhilam Navtashchramam Dashtaha (multiplication of two numbers of three digits)

Unit 2	**Division and Divisibility :** Part A: Division 1. Nikhilam Navtashchramam Dashtaha (two digits divisor) 2. Paravartya Yojyet method (three digits divisor) Part B: Divisibility 1. Ekadhikenpurven method (two digits divisor) 2. Eknunenpurven method (two digits divisor)
Unit 3	**Factorisation /LCM/HCF**
Unit 4	**Solution of Linear Simultaneous Equations :** Simple equations, Simultaneous Simple Equations, Quadratic Equations, Cubic Equations, Simultaneous Quadratic Equations.
Unit 5	**Power and Root Power :** (i) Square (two digit numbers), (ii) Cube (two digit numbers). (iii) Square root (four digit number) (iv) Cube root (six digit numbers) [Self Study and assignments]

Text and Reference Books

1. Vedic Mathematics,Jagadguru Swami Sri BHARATI KRSNA TIRTHAJI MAHARAJA, Motilal Banarsi Das Publishing House, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
3. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
5. Leelavati, Chokhambba Vidya Bhavan, Varanasi.
6. Bharatiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi

Assessment:

ISEI:	Shall be based on Class Tests/ Assignments/Quizzes/Presentations/ Course Projects
ISEII:	Shall be based on class test.

Mapping of Course outcome with Program Outcomes

Course Outcome	PO I	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	POI 0	POI I	POI 2
COI												
CO2												
CO3												

Assessment Pattern

Assessment Pattern Level No.	Knowledge Level	ISE1	ISEII	ESE
Kl	Remember	05	05	10
K2	Understand	05	05	20
K3	Apply	-	-	-
K4	Analyze	-	-	-
KS	Evaluate	-	-	-
K6	Create	-	-	-
Total Mars 50		10	10	30

Assessment table

Assessment Tool	K2	K2	K2
	COl	CO2	CO3
ISE I (10Marks)	10	-	-
ISE II (10Marks)	-	10	-
ESE (30Marks)	10	10	10

Prof. Santosh Attipamlu

Mini-Project -II

EEVSE5002: (Skill based)	
Teaching Scheme	**Examination Scheme**
Practical: 4 Hrs/Week	ISE III : 25 Marks
Credits : 02	End Semester Exam : 25 Marks

Course Description: The student shall collect, review, compile, comprehend, present research literature and identify the problem for the dissertation in the field of Electrical Power System. Students will present seminars on work done by them on any topic of recent technology. The seminar may include some simulation carried out by the student.

Course Objectives:

- To understand the "Product Development Process" including budgeting through Mini Project
- To plan for various activities of the project and distribute the work amongst team members
- To inculcate electronic hardware implementation skills
- To develop student's abilities to transmit technical information clearly and test the same by delivery of Seminar based on the Mini Project
- To understand the importance of document design by compiling Technical Report on the Mini Project work carried out
- **Course Outcomes:** At the end of course students will be able to **:**
- Understand, plan and execute a Mini Project
- Implement electronic hardware by learning PCB artwork design, soldering techniques, testing, and troubleshooting etc.
- Prepare a technical report based on the Mini project
- Deliver technical seminar based on the Mini Project work carried out
- **Course Contents:**
- Mini Project Work should be carried out in the Laboratory.
- Data sheets may be referred, well known project designs ideas can be necessarily adapted from recent issues of electronic design magazines
- Hardware/Software based projects can be designed
- Following areas are just a guideline
- Instrumentation and Control Systems
- Power Electronics
- Embedded Systems/ Microcontroller based projects should preferably use Microchip PIC controllers/ATmega controller/AVR microcontrollers
- Power system based
- Demonstration and Group presentations. Logbook for all these activities shall be maintained and shall be produced at the time of examination
- A project report with following contents shall be prepared:
    - Specifications/Block diagram/Circuit diagram/Selection of components, calculations
    - Simulation results
    - Layout versus schematic verification report

- Testing procedures/Test results Conclusion

Term Work:

The Mini Project with Seminar shall consist of collection of literature from a chosen field of Electrical Engineering from various sources such as refereed journals, proceedings of national international conferences, PG/PhD theses etc. Based on the literature survey, case studies, data collection, surveys, pilot studies, mathematical/analytical modeling, etc., as necessary the candidate shall define the problem for the dissertation.

The candidate shall prepare a technical report in a prescribed format and present before a panel of examiners consisting of a guide and at least one faculty member of the department.

Viva Voce Examination: It consists of two parts.

Part-I: Mid-Term Evaluation for 25 Marks: A mid-term evaluations for 25 marks out of 50 marks shall be done as per the schedule given in the institute academic calendar. Students should prepare a powerpoint presentation and present before the panel of examiners and class students and should be able to answer questions asked by the panel of examiners and class students. Panel of examiner consists of a guide as internal examiner and one faculty member appointed by the DCoE as external examiners. The panel of examiner will assess the contents and presentation and give the suggestions, if any and assign the marks out of 10. In this phase students are expected to collect and present substantial literature.

Part-II: End Semester Evaluation for 25 Marks: Student should prepare technical report in prescribed format duly incorporating suggestions of Part-I and present power point presentation before the panel of examiners and class students. The student should be able to answer the questions asked. The panel of examiner will assess the seminar contents and seminar presentation and assigns the marks out of 25. In this phase the students is expected to define the problem for dissertation through further literature survey, case studies, data collection, surveys, pilot studies, mathematical/analytical modeling, etc., as necessary.

Table 2: Assessment Table:

Assessment Tool	**CO1**	**CO2**	**CO3**
	K1,K2,K4	K2,K3,K4	K2,K3,K4,K5
Term Work- 50 Marks	15	15	20
Viva-voce Assessment- 50 Marks	15	15	20

Table 3: Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Term Work Assessment**	**Viva-voce Examination**
K1	Remember	10	10
K2	Understand	10	10
K3	Apply	10	10
K4	Analyze	10	10
K5	Evaluate	10	10
Total Marks		**50**	**50**

Semester III

EEDIS5020: Dissertation Phase- I	
Teaching Scheme	**Examination Scheme**
Practical: 20 Hrs/Week	Term Work : 100 Marks
Credits :10	Viva-voce :100 Marks
	Total : 200 Marks

Students will present seminars on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have the following structure.

1. Head of the department
2. Guide- Member
3. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.

Semester IV

EEDIS5021: Dissertation Phase - II	
Teaching Scheme	**Examination Scheme**
Practical: 32 Hrs/Week	Term Work : 150 Marks
Credits :16	Viva-voce :150 Marks
	Total : 300 Marks

Students will present seminars on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have the following structure.

4. Head Of the department
5. Guide- Member
6. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.