Government College of Engineering,
Chhatrapati Sambhajinagar

(An Autonomous Institute of Government of Maharashtra)

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

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Curriculum for M. Tech. in Electrical Machine Drives
(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 conducive 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 Sambhajinagar

Department of Electrical Engineering

M. Tech EMD (Structure and Syllabus Effective from 2023-24 onwards)

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 III**	**ESE**	**Total**
1	PCC	EEPCC5002	Advanced Power Electronics	3	0	-	3	20	20	60	100
2	PCC	EEPCC5003	Electrical Machine Modeling and Analysis	3	-	-	3	20	20	60	100
3	PCC	EEPCC6001	Electric Vehicles	3	-	-	3	20	20	60	100
4	PCC	EEPCC6002	Lab Simulation-I			2	1		25	-	25
5	VSEC-I	EEVSE6001	Lab-Hardware		1	2	2		25	25	50
6	PEC		Program Elective-1	3	-	-	3	20	20	60	100
7	PEC		Program Elective-2	3	-	-	3	20	20	60	100
8		MERMC5001	Research Methodology	4	-	-	4	20	20	60	100
			Total	**19**	**1**	**4**	**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**
EEPEC6001	**Industrial Automation & Control**	EEPEC5003	Power System Reliability
EEPEC6002	**PWM Techniques for Power Converters**	EEPEC5004	Smart Grid Technology
EEPEC6003	**Embedded Systems**	EEPEC5005	Data Science Applications in Electrical Engineering
EEPEC6004	**Electromagnetic Interference Techniques**		

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

Semester II

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 III	ESE	Total
1	PCC	EEPCC6011	Advanced Control Systems	3	-	-	3	20	20	60	100
2	PCC	EEPCC6012	Advanced Electric Drives	3	-	-	3	20	20	60	100
3	PCC	EEPCC6013	Lab Simulation -II	-	-	4	2	-	25	25	50
4	PCC	EEPCC6014	Lab AED			2	1	-	25	-	25
5	PCC		Program Elective-3	3	-	-	3	20	20	60	100
6	PCC		Program Elective-4	3	-	-	3	20	20	60	100
7	PCC		Program Elective-5	3		-	3	20	20	60	100
8	HSS (AEC)	EEAEC5001	Technical Presentation	3	-	-	3	20	20	60	100
09	OE- I	EEOEC5001	Introduction to Electric Vehicle	3	-	-	3	20	20	60	100
10	VSEC-II	EEVEC6002	Mini project		-	4	2	-	25	25	50
			Total	**21**	**0**	**10**	**26**	**140**	**215**	**460**	**825**

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

*List of Program Electives III, IV & V			
Course Codes	**Program Electives**	**Course Codes**	**Program Electives**
EEPEC6010	**Reliability and Condition Monitoring**	EEPEC5013	Integration of Renewable Energy Sources
EEPEC6011	**Electrical Drives Applications**	EEPEC5014	Life Estimation of Power Equipments
EEPEC6012	**Digital Control systems**	EEPEC5015	Optimization Techniques
EEPEC6013	**Energy Storage Systems**	EEPEC5016	Smart Appliances & IoT
EEPEC6014	**Machine Learning & Applications**	EEPEC5017	Real Time Control Power systems
EEPEC6015	**Optimal Control Systems**	EEPEC5018	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 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	EEDIS6020	Dissertation Ph I			20	10		100	100	200
2	HSS		Entrepreneurship/ Economics/ Management Courses	3			3	20	20	60	100
3	OE- II	EEOEC5002	Smart Grid	3	-	-	3	20	20	60	100
4	IKS			2			2	20		30	50
	Total			**8**	**0**	**20**	**18**	**60**	**140**	**250**	**450**

Open Elective – II*

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

S.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 - Smart Grid Systems	Electrical Engineering
6	ECOEC6006 - Soft Computing	Electronics & Telecommunication

HSSM: - Entrepreneurship / Economics / Management Course

S.No.	Open Elective – II Course	Course Offering Department
1	MEEEM6001 – Entrepreneurship Development	Mechanical Engineering
2	ECEEM 6002 – 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	EEDIS6021	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**

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Dated: 23rd Nov 2023

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 cycloconverter
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
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

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

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 the 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
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			
Total Marks 100		20	20	60

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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

EEPCC6001: 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 DriveTrain, 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. Simulations 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+K 3
	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

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

Designed by
Prof. V. P. Dhote

EEPCC6002: Simulation Laboratory-I

Teaching Scheme	Examination Scheme	
Practical: 02 Hrs/Week	ISE III	: 25 Marks
Credits: 01	Total	: 25 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.

This lab may includes the design, development/ simulation of experimental prototypes of following experiments. The students can form a group of two or three and develop at least six prototypes from the following list.

1. Development of 48 V uncontrolled AC-DC converter using auto transformer.
2. Development of SCR based full wave converter.
3. Development of control circuit for SCR based full wave converter using either Arduino or microcontroller
to generate triggering pulses.
4. Development of single phase/three phase bridge inverter using MOSFET.
5. Control circuit for single/three phase bridge inverter (MOSFET) with sinusoidal PWM. Use preferably
Arduino/microcontroller to generate triggering pulses.
6. Development of single/three phase bridge inverter using IGBT.
7. Control circuit for Single/Three phase bridge inverter (IGBT) with single pulse/multi pulse/sinusoidal
modulation Use preferably Arduino/microcontroller to generate triggering pulses.
8. Development of MOSFET based DC-DC buck converter.
9. Development of MOSFET based DC-DC boost converter.
10. Control circuit for MOSFET based DC-DC buck converter.Use preferably Arduino/microcontroller to generate triggering pulses.
11. Control circuit for MOSFET based DC-DC boost converter. Use preferably Arduino/microcontroller to generate triggering pulses.
12. Design and development of PCB using suitable software.

Term work:

The term work shall consist of submitting a report based on the selected experimental prototype. The course teacher will assess the term work.

EEPCC5205: Lab-Hardware		
Teaching Scheme	Examination Scheme	
Practical: 02 Hrs/Week	ISE III	: 25 Marks
Tutorial 01	Total	: 25 Marks
Total Credits: 02		

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

CO1	Determine the characteristics of power devices and converters
CO2	Implement control circuits for power converters
CO3	Determine the performance of power converters
CO4	Determine the performance of Z-source and resonant converters

List of Experiments

1. Static characteristics of MOSFET and IGBT
2. PV characteristics and Implementation of MPPT
3. Analysis of DC-DC converters (a) Buck converter, (b) Boost converter, and (c) Buck-Boost converter
4. Closed loop control of Buck and Boost converter
5. Quasi-square wave control of a Single phase Full bridge VSI
6. Unipolar and bipolar PWM techniques for single-phase half-bridge and full-bridge inverters.
7. 120˚and 180 operation of three-phase inverter and selective harmonic elimination for three- phase inverter
8. Sine-PWM techniques for three-phase two-level inverters.
9. Space vector modulation for a three-phase VSI
10. Pulse width modulation control of Single phase AC voltage controller
11. Single phase Five level cascaded H-Bridge inverter
12. Hysteresis current control of a single phase inverter
13. Control of Front-end active rectifiers/Bidirectional Converters
14. Control of Z-source inverter
15. Control of Resonant DC - DC converters
16. (a) Study of instantaneous power in various frames of reference.
(b) Study of torque produced in an induction machine in '*abc*' and '*qd0*' frames.
17. Implementation of buck and boost dc-dc converters.
    a. Design of various elements such as inductor, capacitor for continuous and discontinuous current operation.
    b. State-space modeling.
    c. Study the dynamic behavior of the DC-DC converters through numerical integration methods.

18 Study on the design of PI controllers and stability analysis for a DC-DC buck Converter.

19. Sine-PWM techniques for single-phase half-bridge, full-bridge and three-phase inverters.
20. Programming of sine-triangle PWM technique in simulation environment.
21. Space vector modulation (SVM) for three-phase two-level inverters using classical and Kim-Sul methods.

22. Closed-loop implementation single-phase high power factor rectifiers (Boost rectifier and PWM rectifier).
23. Multicarrier PWM techniques for three-phase diode clamped and cascade H- bridge multilevel inverters.
24. Study of the dynamic performance of a V/Hz controlled induction motor drive using the *dq0* model.

Program Electives in Semester I

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			
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

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

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

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

EEPEC5005 :Data Science Applications in Electrical Engineering	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hr/Week	ISE III : 20 Marks
Credits: 3	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 perception 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- 5	**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.

EEPEC 6001 Industrial Automation & Control			
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: - Provides the student with basic knowledge of industrial automation. This course introduces the basic concept of process control, building blocks of automation, various control configurations.

Course Objectives: -The objectives of the course are to

1. Describe various measurement systems using sensors
2. Explain various process control configuration
3. Illustrate various controllers used in industry
4. Explain PLC, SCADA, PDC systems
5. Describe and Illustrate valves used in Industry

Unit wise Course Outcomes expected: Students will be able to

CO1. Use various sensors for measurement of physical parameters
CO2. Analyze various control configurations used in process control
CO3. Use controller such as P, PI, PID
CO4. Design systems using PLC, SCADA, DDC configuration as control values for application
CO5.Compare various control valves

Detail syllabus:

Unit-I	**Introduction to Industrial Automation and Control** Architecture of Industrial Automation Systems, Introduction to sensors and measurement systems, Temperature measurement, Pressure and Force measurements , Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH etc., Signal Conditioning and Processing
Unit-II	**Introduction to process Control:** Evolution of Process Control Concept , Definition and Types of Processes Benefits, Difficulties and Requirements of Process Control Implementation , Classification of Process Variables, Open-loop Vs Closed Loop control, Servo Vs Regulator Operation of Closed Loop System, Feedback and Feed forward Control Configuration, Steps in Synthesis of Control System, process dynamics and Mathematical Modeling, Aspects of the process dynamics, Types of dynamic processes, Common systems, Mathematical Modeling, Cascade, Feed forward, and Ratio Control, multi loop Cascade Control, Feed forward Control, Feed forward- Feedback control configuration, Ratio Controller

Unit-III	**Type of Controllers:** Introduction, PID control, Classification of Controllers, Controller Terms, Introduction, Transfer functions of closed loop, Proportional controller in closed loop, Integral controller in closed loop, Proportional-integral controller in closed loop, Proportional derivative controller in closed loop, Proportional-integral-derivative controller in closed loop, Integral windup and Anti-windup, Comparison of various controller configurations, Controller Tuning
Unit-IV	**PLC, DCS and SCADA system:** Introduction, Basic parts of a PLC, Operation of a PLC, Basic symbols used in PLC realization, Difference between PLC and Hardwired systems, Difference between PLC and computer, Relay logic to ladder logic, Ladder commands, Examples of PLC ladder diagram realization, PLC timers, PLC counters and examples, Classification of PLCs. History of DCS, DCS concepts, DCS hardware & software, DCS structure, Advantages and disadvantages of DCS, Representative DCS, SCADA, SCADA hardware & software, DDC, Components and Working of DDC, Benefits of DDC, Digital controller realization, discrete domain analysis, Networking of sensors, Actuators, controllers, CANBUS, PROFIBUS AND MODBUS..
Unit-V	**Control Valves:** Introduction, Common abbreviations in the valve industry, Definitions of terms associated with valves, Control Valve characteristics, Valve classifications & types, Selection criteria for control valves, P and I diagram, Definitions of terms used in P and I diagrams, Instrument identification, Examples of P and I diagram, various automation devices used in industry, Control of Machine tools, Analysis of a control loop, Introduction to Actuators: Flow Control Valves, Hydraulic Actuator Systems : Principles, Components and Symbols, Pumps and Motors, Proportional and Servo Valves Pneumatic Control Systems, System Components, Controllers and Integrated Control Systems, Electric Drives, Energy Saving with Adjustable Speed Drives.

Text books:

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

1. Teaching Strategies:

The teaching strategy is planed 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.

2. ISE III Assessment: The teacher's assessment should be done based on any one or combination of any two of the following scheme.

1. Assignments : 10/20 Marks
2. Objective type test : 10/20 Marks
3. Modeling of electrical machines using any electrical software : 10/20 Marks
4. Technical/Industrial visit report / Quiz : 10/20 Marks

3. Assessment table:

Assessment Tool	K1+K2+ K3	K1+K2+ K3	K1+ K2	K2	K1+K3
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I 20 Marks	10	10			
ISE III 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**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	10		20
K2	Understand	10	10	20
K3	Apply		10	14
K4	Analyze			06
Total		20	20	60

Designed By:
Dr. S. S. Kulkarni

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

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

Teacher 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**

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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)	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

EEPEC6003 Embedded Systems	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Hr/Week Total Credits : 03	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks 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 Vonneuman/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.

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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

6. Chuck Helebuyck "Programming PIC microcontrollers with PIC basic"

7.Qing Li, "Real Time Concepts for Embedded Systems", Elsevier, 2011.

8.Shibu K.V, "Introduction to Embedded Systems", Mc Graw Hill.

9. Frank Vahid, Tony Givargis, "Embedded System Design", John W

10. Milan Verle "PIC Microcontrollers-programming in Basic"

ISE III 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**	**ISE I**	**ISE III**	**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

EEPEC6004: Electromagnetic Interference and Compatibility		
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

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

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

MERMC5001: Research Methodology		
Teaching Scheme	**Examination Scheme**	
Lectures: 4 Hrs/Week	ISE I Test	: 20 Marks
Tutorial: 0 Hr/Week	Teachers Assessment	: 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 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, opinion are, 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 Description: 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 Ushtrasan) 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 by Yoga Teachers. Meditation trainers will observe intrinsic goodness, right attitude and happy and joyous way of doing things.

Club activities: Government Engineering College Chhatrapati Sambhajinagar 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 semester. Faculty coordinators will coordinate along with students bodies the activities of club.

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

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

Course Description:
This course is a mandatory 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, Lyapunovs 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:

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 10Marks
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	-	-	-
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)	10	10	-	-	-
ISE III (20 Marks)	4	4	4	4	4
ESE (60 Marks)	12	12	12	12	12

Designed by Dr. S. S. Kulkarni

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

EEPCC6012: Advanced Electric Drives	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 0 Hrs/Week Credits **:** 03	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks 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 **Electric Drives**.
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	Apply the theory of transformations to derive the dynamic (dq0) model of an induction motor
CO2	Understand Dynamic Model of an induction motor
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	Theory of Transformations: Concept of space vector, direct and quadrature axis variables, various types of Krause transformation, condition for power invariance, Expression for power with various types of transformation, Transformations between reference frames, Clarke and Park's Transformations, Variables observed from various frames
Unit-2	Dynamic Model of an induction motor: Inductance matrices of induction motor, Voltage and torque in machine variables, Derivation of dq0 model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables
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 attern:

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 Assessment (20 Marks)	4	4	4	4	4
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Prof. V.P.Dhote

EEPCC6013: Lab Simulation -II		
Teaching Scheme	**Examination Scheme**	
Practicals: 4 Hrs/Week	ISE III	: 25 Marks
Credits : 02	ESE	: 25 Marks
	Total Marks	:50 Marks

Students should perform total **TEN** experiments.

Any 3 from following-

1. Generalized program to determine Lead compensator of given network/system.
2. Generalized program to determine Lag compensator of given network/system.
3. Generalized program to determine Lead-Lag compensator of given network/system.
4. Generalized simulation/program to Nonlinearity of PV/ Diode cell
5. Generalized simulation/program to Nonlinearity of any device/application

Any 3 from following-

1. Familiarization with various features of the Scilab / MATLAB/Simulink environment.
2. Demonstrating the phenomenon of aliasing due to under-sampling.
3. Implementation of algorithms 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.

EEPCC5213: Lab Electric Drives			
Teaching Scheme		**Examination Scheme**	
Practical	: 2 Hrs/Week	ISE III	: 25Marks
Total Credits	: 1	Total Marks	: 25 Marks

Course Objectives

The objectives of the course are to-

1. To expose the students to a variety of electric drives.
2. To provide hand-on experience in ac and dc drives.

Course Outcomes: After completion of this course students will be able to

CO1. Write a code for the selected DSP/microcontroller to controls the dc motor drives.
CO2. Write a code for the selected DSP/microcontroller to controls the ac motor drives.
CO3. Develop technical writing skills important for effective communication
CO4. Acquire teamwork skills for working effectively in groups

List of the Experiments:

1. Three experiments based on study and / or simulation of voltage fed , current fed converters and electric drives (mentioned in the syllabus) using MATLAB/SIMULINK/PSPICE
2. Three experiments based on study and / or experimentation on following electrical drives
   a. DC motor drive
   b. V/F induction motor control drive
   c. Vector control of induction motor drive
   d. Synchronous motor drive
   e. Special machines

Term work:

The term work shall consist of submitting a file for minimum six experiments performed with neatly written records of the study, circuit diagrams, observations, and graphs with results.

The term work will be assessed by the course coordinator

Practical Examination:

The Practical Examination shall comprise of performing the experiment and viva voce on the syllabus

The practical will be assessed by two examiners, one will be internal examiner and other will be external examiner appointed by DSB

Sample Assessment Pattern:

Assessment Pattern Level No.	Skill Level	Term Work	Practical Examination & viva voce
S1	Imitation	05	05
S2	Manipulation	10	10

S3	Precision	10	10
S4	Articulation	00	00
S5	Naturalization	00	00
Total		25	25

Details	**Term Work**	**Practical Examination & viva voce**
Preparation (S1)	05	05
Conduct of Experiment (S2)	05	05
Observation and Analysis of Results (S3)	05	05
Record (S2)	05	05
Presentation/ Viva-Voce (S3)	05	05
Total	**25**	**25**

Sample Assessment Table

Assessment Tool	**S1,S2,S3**	**S1,S2,S3**	**S1,S2,S3**	**S1,S2,S3**
	C01	C02	CO3	CO4
Term Work (25 Marks)	08	07	05	05
Practical Examination & Viva Voce (25 Marks)	08	07	05	05

Designed by Prof. V. P. Dhote

EEVEC6001 : MINI PROJECT	
Teaching Scheme Practical: 04 Hrs/Week Credits: 02	**Examination Scheme** ISE III : 50 Marks Viva-voce : 50 Marks Total : 100 Marks

Prerequisite: Not applicable

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. Student will present seminar on work done by them on any topic of the 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
- References

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 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. Student should prepare a power point 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 guide as internal examiner and one faculty members appointed by the DCoE as external examiners. The panel of examiner will assess the contents and presentation and give the suggestions, if any and assigns the marks out of 25. In this phase student is 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.

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

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
K6	Create	--	--
Total Marks		**50**	**50**

List of Program Electives in Semester II

EEPEC5013: Integration of Renewable Energy Sources	
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 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”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9
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
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

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

EEPCC5014: Life Estimation of Power System Equipment	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Hr/Week Total Credits : 3	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks 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/ Reference 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 planed 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.

Teacher's 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
Class Test 20 Marks	10	10			
Teachers Assessment 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	
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, Teaching Learning Based Optimization, and other Non-traditional Optimization Algorithms, applications.

Unit 5	Applications to Power system: Economic Load Dispatch in thermal and Hydro-thermal system Unit commitment problem, reactive power optimization. Optimal power flow, LPP and NLP techniques to Optimal flow problems.

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 Non-Linear 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, 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	5	5		
Teachers Assessment (20 Marks)				10	10
ESE Assessment (60 Marks)	10	20	10	10	10

Designed by Dr. S. P. Ghanegaonkar

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

Course Outcomes: 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 Lectures : 03 Hrs/Week Tutorial : 00 Total Credits : 03	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks 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.

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

EEPEC6010: Reliability and Condition Monitoring			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	ISE I	: 20 Marks
Tutorial	: 0 Hr/Week	ISE III	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Course Objective:

The objectives of the course are to

1. Know engineering system monitoring and fault diagnosis and explains the basic concepts of condition monitoring.
2. Know how modern technology, quality control and environmental issues have affected current thinking.
3. Protect themselves and others in the workplace and focuses on the safety measures needed when Carrying out monitoring activities, especially those for isolating equipment.
4. Know how to use a range of condition monitoring equipment and will develop the skills and knowledge required for the location and identification of faults in engineering systems.
5. Learners will be required to select the appropriate monitoring technique and equipment based on the type of plant or equipment being monitored and the conditions checked.

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

CO1	Know the health and safety requirements relevant to monitoring and fault diagnosis of engineering Systems.
CO2	Know about system monitoring and reliability.
CO3	Use monitoring and test equipment
CO4	Carry out fault diagnosis on electrical engineering equipment
CO5	Develop model for improvement in life of electrical equipment.

Detailed Syllabus:

Unit 1	**Introduction to the field of machine condition monitoring:** methods, tools used to monitor a machine, diagnostics and prognostics, reliability, maintenance practices, health usage monitoring, Frequency of monitoring, infrared thermography, Ultrasounds
Unit 2	**Failure analysis:** Failure mode-effect and criticality analysis, fault tree analysis. Breakdown mechanisms in gases, liquids, vacuum, solids. maintenance strategies (breakdown, preventive, planned, scheduled, diagnostic, total productive maintenance, reliability centered maintenance) organization for maintenance, maintenance requirements, maintenance planning and work control, maintenance records, frequency of maintenance, cost of maintenance, maintenance effectiveness
Unit 3	**Condition Monitoring of Transformer:** Type of faults, duration and the impacts Interpretation of gases generated in Oil-Immersed Transformer, Transformer winding and core deformation detection utilizing SFRA technique, Methods of Dissolved Gas Analysis (DGA), partial discharge

Unit 4	**Diagnosis of electrical equipment:** Motors, generators, Configuration, problems, diagnosis and solutions, Causes of motor failure, remedies. Signature analysis, condition monitoring of induction motor, power cables
Unit 5	**Substation Maintenance:** Types – Routine, Preventive, Planned, Predictive, Break-down, Emergency maintenance, on-line maintenance of different equipments, Condition monitoring of power apparatus, New advanced techniques in diagnosis and monitoring of electrical equipment.

Text and Reference Books:

1. Advances in high voltage engineering, edited by A. Haddad and D. Warne, IEE Power and EnergySeries, 2004.
2. Electrical Insulation in Power Systems, N. H. Malik, A. A. Al-Arainy and M. I. Qureshi, Marcel Dekker,1997.
3. Insulation of High Voltage Equipment, V.Y. Ushakov, Springer-Verlag, 2004.
4. High Voltage Engineering Fundamentals, KuffelZaengelKuffel, Newnes
5. K. B. Raina, S. K. Bhattacharya, Electrical Design, Estimation and costing, wiely eastern limited NewDelhi 1991.
6. S. L. Uppal- Electrical Power- Khanna Publishers Delhi.
7. Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence, W.H. Tang, Q.H. Wu ,ISBN: 978-0-85729-051-9
8. Handbook of Condition Monitoring: Techniques and Methodology Edited by A. Davies
9. Advances in Electrical Engineering and Electrical Machines Editors: DehuaiZheng, ISBN: 978-3- 642-25904-3

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	10	4	15
K2	Understand	5	4	20
K3	Apply	5	4	25
K4	Analyze		4	

K5	Evaluate		4	
K6	Create			
Total Marks 100		20	20	60

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K2+K3	K2+K3	K2+k3	K2+K3	K2+ K3	K2+ K3
	C01	C02	C03	CO4	CO5	CO6	CO7
Class Test (20 Marks)	10	05	05				
Teachers Assessment (20 Marks)	4	4	4	4	4		
ESE Assessment (60 Marks)	12	12	06	06	06	06	12

Designed by
Dr. N. J. Phadkule

Approved in XXVIIth Academic Council
Dated: 23rd Nov 2023

EEPEC6011: Electrical Drives Application	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 20 Marks
Tutorials : 0 Hr/Week	ISE III : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description:
Electrical Drives Applications is a one-semester course. The students can opt this course as a professional elective.

Course Objectives:
The objectives of the course are to:
1. Learn basic concepts of energy efficient motors
2. Know energy conservation issues in electrical drives
3. Learn electric drive systems for electric traction
4. Understand Industrial applications of electrical drives

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

CO1	Understand basic concepts of energy efficient motors
CO2	Explain energy conservation issues in electrical drives
CO3	Explain electric drive systems for electric traction
CO4	Discuss industrial applications of electrical drives

Detailed Syllabus :

Unit-1	**Energy Efficient Motors:** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit.
Unit-2	**Energy Conservation in Electrical Drives:** Losses in electrical drives system, measures for energy conservation in electrical drives, use of efficient semiconductor converters, use of variable speed drives, use of variable speed drives, Energy efficient operation of drives, improvement of power factor, improvement of supply quality, Single to three phase converters in rural applications, regular and preventive maintenance

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Unit-3	**Electric Traction:** General features of electrical traction, Mechanics of train movement, Nature of traction load, Speed-time curves, Calculations of traction drive rating and energy consumption, Train resistance, Adhesive weight and coefficient of adhesion, Tractive effort for acceleration and propulsion, Power and energy output from driving axles, Methods of speed control and braking of motors for traction load, Electric drive systems for electric traction. Electric cars and trolley buses, energy considerations. Electric and Hybrid Vehicles
Unit-4	**Industrial Applications:** Various processes involved, Process/operation—Requirements of load—Suitable Drive selection, drives employed, their ratings and recent advancements in the drives for following applications Rolling/Steel mill, Paper mill, Cement mill, Textile mill, Sugar mill, Coal mining, Machine tool applications and Petrochemical industry

Text/ Reference Books:

1. Energy efficient electric motors by John C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
2. Fundamentals of Electrical Drives by G. K. Dubey, Narosa Pub House (2nd Edition)
3. Electric Traction by H. Partab, Dhanpat Rai& Sons.
4. Electric Drives by N. K. De & P. K. Sen, Prentice Hall of India Eastern Economy Edition
5. A first course on Electrical Drives by S. K. Pillai Wiley Eastern Ltd.

ISE III Assessment:

Teachers Assessment of 20 marks is based on attendance of the student and one of the / or combination of a few of the 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 to the subject
2. Assignments
3. Quiz
4. Surprise test
5. MCQ

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**
	C01	C02	C03	CO4
Class Test (20 Marks)	10	10	-	-
TA (20 Marks)	5	5	5	5
ESE (60 Marks)	15	15	15	15

Designed by Prof. V. P. Dhote

EEPEC6012: Digital Control Systems	
Teaching Scheme Lectures : 03Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I :20 Marks ISE III : 20 Marks End -Semester Exam : 60 Marks

Pre- Requisite: Advance Control System

Course description: The purpose of this course is to teach students the fundamentals of Digital Control Systems.

Course objectives: -The objectives of the course are to

1. Explain sampling and reconstruction
2. Illustrate transform analysis of sampled data system
3. Explain the design of digital controls
4. Describe self-tuning
5. Illustrate the control applications of microprocessor based control system

Unit wise Course Outcomes expected:

After completion of this course students will be able to

CO1: Model the System In Discrete Form
CO2. Analyze the stability of system in discrete form
CO3. Design sample data control system using frequency domain techniques
CO4. Design sample data control system using time domain techniques
CO5. Represent system in state space form

Detailed syllabus:

Unit-I	**Sampling and Reconstruction:** Sampled data control system, Digital to Analog conversion, Analog to Digital conversion, Sample and Hold operation
Unit-II	**Transform analysis of Sampled Data systems:** Linear difference equation, The pulse response, The Z-transform, The pulse transform, Block diagram analysis of sampled data systems, Z-domain equivalents to S-domain compensator, Stability analysis, Systems with dead time
Unit-III	**Transform design of Digital Controls:** Design specification, Design on ω plane, Design on z plane, Digital PID controller, Discrete time state equations similarity transformation
Unit-IV	**Self-tuning control:** Identification problem, principle of least squares, self-tuning regulators

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Dated: 23rd Nov 2023

Unit-V	Case studies, Temperature control system, Stepping motors

Text Books:
Digital Control Engineering, M. Gopal, New Age International Publications, Second Edition

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 one of the /or combination of the few of the following.

1) Assignment
2) Multiple choice question

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	10	05	05	5	5
Teachers Assessment 20 Marks	4	4	4	4	4
ESE Assessment 60 Marks	12	12	12	12	12

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment /Assignment**	**End Semester Examination**
K1	Remember	5	10	15
K2	Understand	10	10	20
K3	Apply	5		25
K4	Analyze			
K5	Evaluate			
K6	Create			
Total		20	20	60

Designed by
Dr. S. S. Kulkarni

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

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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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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 20 Marks			10	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 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 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 Discriminate Analysis, Naïve Bayes – Kernal Method: Support Vector Machine (SVM) – Kernal function – Kernal 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 Auto Encoder (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/

EEPEC6015: Optimal Control Systems	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Hr/Week Total Credits : 3	**Examination Scheme** ISE I : 20 Marks ISE III : 20 Marks End -Semester Exam : 60 Marks

Course Description: Optimal control is the problem of determining the control function for a dynamical system to minimize a cost related to the system trajectory. The overall aim of the course is to provide an understanding of the main results in calculus of variations and optimal control.

Course Objectives: -The objectives of the course are to

1. Explain the formulation of optimal control problem
2. Explain the minimization of function using calculus of variation
3. Explain the dynamic programming
4. Explain minimization function using two boundary value problem
5. Explain optimal feedback

Unit wise Course Outcomes expected:

Students will be able to

CO1.Formulate optimal control problem
CO2. Minimize the function using calculus of variation
CO3. Solve dynamic programming problem
CO4. Minimize function using two boundary value problem
CO5. Solve optimal feedback problem

Detailed Syllabus:

Unit-I	**General Mathematical Procedures:** Introduction, Formulation of the Optimal Control Problem, The Characteristics of the Plant, The Requirements Made Upon the Plant, Minimum Time Problem, Minimum Energy Problem, Minimum Fuel Problem, State Regulator Problem, Output Regulator Problem, Tracking Problem, The Nature of Information about the Plant Supplied to the Controller
Unit-II	**Calculus of Variations:** Minimization of Functions, Minimization of Functional, Functional of a Single Function, Functional Involving an Independent Functions, Constrained Minimization, Formulation of Variation Calculus Using Hamiltonian Method, Minimum Principle: Control Variable Inequality Constraints, Control and State Variable Inequality Constraints

Unit-III	**Dynamic Programming:** Multistage Decision Process in Discrete – Time, Principle of Causality, Principle of Invariant Imbedding, Principle of Optimality, Multistage Decision Process in Continuous – Time Hamilton Jacobi Equation
Unit-IV	**Numerical Solution of Two- Point Boundary Value Problem:** Minimization of Functions, The Steepest Descent Method, The Fletcher – Powell Method, Solution of Two Point Boundary Value Problem
Unit-V	**Optimal Feedback Control:** Introduction, Discrete Time Linear State Regulator, Continuous Time Linear State Regulator, Time Invariant Linear State Regulators, Continuous – Time Systems, Discrete Time Systems, Discretization of Performance Index. Numerical Solution of the Riccati Equation: Direct Integration, A Negative Exponential Method, An Iterative Method, Use of Linear State Regulator results to Solve Other Linear Optimal Control Problems. Output Regulator problem, Linear Regulator with a Prescribed Degree of Stability, A Tracking Control Scheme, Discrete Time Extensions

Text/ Reference Books:

1. A. E. Bryson and Y. C. Ho, Applied Optimal Control, Hemisphere/Wiley, 1975.
2. D. E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall, 1970.
3. B. D. O. Anderson and J. B. Moore, Optimal Control, Prentice-Hall, 1990.

1. Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works, NPTEL. 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.

2. Teacher's 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

3. Assessment table:

Assessment Tool					
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I Class Test 20 Marks	10	10			
ISE III 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	10		20
K2	Understand	10	10	30
K3	Apply		10	10
K4	Analyze			
K5	Evaluate			
K6	Create			
Total		20	20	60

Designed by: Dr. S. S. Kulkarni

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 Assessment : 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 work place 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 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.

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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, Harward University, U.S.
7. Business Communication for Managers by Payal Mehra, Pearson Publication, Delhi. Course Outcomes

Open Elective- I

EEOEC 5001:(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 FTR, Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Nonconstant FTR.
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, Switch 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 PPS 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

Open Elective II EEPEC5002 : Smart Grid	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I : 20 Marks
Tutorial: 0 Hrs/Week	ISE III : 20 Marks
Credits : 03	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- Concept of Resilient & Self-Healing Grid, – 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: Smart Substations, Substation Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Wide Area Measurement System(WAMS), Phase Measurement Unit 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 Technologie such as battery, SMES, Pumped Hydro,Compressed Air Energy storage –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 and protection of Smart Power Grid System** 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			
Total Marks 100		20	20	60

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Mini-Project -II

EEVEC6001: (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. Student will present seminar 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 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. Student should prepare a power point 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 guide as internal examiner and one faculty members appointed by the DCoE as external examiners. The panel of examiner will assess the contents and presentation and give the suggestions, if any and assigns the marks out of 10. In this phase student is 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

EEDIS6020 : DISSERTATION PHASE – I		
Teaching Scheme	**Examination Scheme**	
Practical: 20 Hrs/Week	ISE III	: 100 Marks
Credits :10	Viva voce(ESE)	: 100 Marks
	Total	: 200 Marks

Student will present seminar 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 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

EEDIS6021: DISSERTATION PHASE – II			
Teaching Scheme	**Examination Scheme**		
Practical : 32 Hrs/Week	ISE III	: 150 Marks	
Credits :16	Viva-voce	: 150 Marks	
	Total	: 300 Marks	

Student will present seminar 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 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.