Government College of Engineering,

Chhatrapati Sambhajinagar

(An Autonomous Institute of Government of Maharashtra)

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

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

Curriculum for B. Tech. in Electrical Engineering

(New CBCS) (With Effect from Academic Year 2024-25)

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.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

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.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Program Outcomes (Graduates Attributes as per NBA)

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design systems components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, social and environmental consideration. To use modern engineering IT tools to solve and model electrical engineering problems.
4. Conduct investigations of complex problems: Use research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including predictions and modeling to complex engineering activities with an understanding of the limitations
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and consequent responsibility relevant to the professional engineering practice.
7. Environment and sustainability: Understands the impact of professional engineering solutions in societal and environmental contexts, and demonstrates the knowledge of and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual and as a member or leader in diverse teams, and multidisciplinary settings.
10. Communications: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentations, make effective presentations and give and receive clear instructions.
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments.
12. Life-long learning: Recognize the need for and have preparation and ability to engage in independent and life-long learning in the broadest context of technological changes.

Program Specific outcomes of EED of GECA (From institute website)
PSO1. Identify, formulate problems in power system domain and apply subject knowledge to provide solutions
PSO2. Classify, make use of various electrical machines, power electronics circuits and electrical drives for engineering applications and investigate for suitability and troubleshooting
PSO3. Analyze and apply concepts of electronics, control systems and instrumentation for engineering applications

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Teaching and Evaluation Scheme from year 2022-23

Second Year B. Tech. Program in Electrical Engineering

Semester III

Semester III Courses				Teaching Scheme			Continuous Evaluation in terms of Marks					
Sr No	**Category**	**Course Code**	**Course Name**	**TH**	**T**	**PR**	**Credits**	**ISE I**	**ISE II**	**ISE III**	**ESE**	**Total**
1	BSC		Mathematics –III	2	1	-	3	15	15	10	60	100
2	PC- I	EEPC2001	Network Analysis	3		-	3	15	15	10	60	100
3	PC- II	EEPC2002	Electrical Machines-I	3		-	3	15	15	10	60	100
4	PC-III	EEPC2003	Electrical Measurement & Instrumentation	3	-	-	3	15	15	10	60	100
5	PCIV	EEPC2004	Analog Electronic Circuits	3	-	-	3	15	15	10	60	100
6	PC- I	EEPC2005	Lab Network Analysis	-	-	2	1	25	-	-	25	50
7	PC-II	EEPC2006	Lab Analog Electronic Circuits	-	-	2	1	25	-	-	25	50
8	PC-III	EEPC2007	Lab: Electrical Machines-I	-	-	2	1	25	-	-	25	50
9	PC IV	EEPC2008	Lab Electrical Measurement & Instrumentation	-	-	2	1	25	-	-	25	50
10	OE -I			3	-	-	3	15	15	10	60	100
11	MC	INMC2010	Environmental Studies	3	-	-	-	15	15	10	60	100
			Total	**17**	**1**	**08**	**22**	**190**	**90**	**60**	**460**	**900**

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

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**	**ISE III**	**ESE**	**Total**
1	ESC	EEES2020	Electromagnetic Field	3	-	-	3	15	15	10	60	100
2	ESC	EEES2021	Numerical Computational Techniques	2	-	-	2	15	15	20	-	50
3	PC-V	EEPC2022	Electrical Machines -II	3	-	-	3	15	15	10	60	100
4	PC-VI	EEPC2023	Power System - I	3	-	-	3	15	15	10	60	100
5	ESC	EEES2024	Renewable Energy Systems	3	-	-	3	15	15	10	60	100
6	PC-V	EEPC2025	Lab Electrical Machines -II	-	-	2	1	25	-	-	25	50
7	ESC	EEES2026	Lab Numerical Computational Techniques	-	-	2	1	25	-	-	25	50
8	OE- II			3	-	-	3	15	15	10	60	100
			Total	**17**	**0**	**04**	**19**	**140**	**90**	**70**	**350**	**650**

 # Industrial Training of minimum 4 weeks after second/third year, for which one credit is awarded in VII semester.

*__ISE I, II__ will be compulsory class tests **and ISE III** will be based on any one of the following components: surprise test, declared test, MCQ test, assignments, PPT presentation, quiz, fabrication of a working model, etc. However, the course coordinator shall declare the method of evaluation at the beginning of the course.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Teaching and Evaluation Scheme from year 2023-24

Third Year B. Tech. Program in Electrical Engineering

Semester V

Semester V Course				Teaching Scheme			Continuous Evaluation in terms of Marks					
Sr No	Category	Course Code	Course Name	TH	T	PR	Credits	ISE I	ISE II	ISE III	ESE	Total
1	PC-VII	EEPC3001	Control Systems- I	3	-	-	3	15	15	10	60	100
2	PC-VIII	EEPC3002	Digital Circuits	3	-	-	3	15	15	10	60	100
3	PC- IX	EEPC3003	Power System-II	3	-	-	3	15	15	10	60	100
4	PE- I			3	-	-	3	15	15	10	60	100
5	HSMC-II			3	-	-	3	15	15	10	60	100
6	OE-III			3	-	-	3	15	15	10	60	100
7	PC-VII	EEPC3004	Lab Control Systems -I	-	-	2	1	25	-	-	25	50
8	PC-VIII	EEPC3005	Lab Digital Circuits	-	-	2	1	25	-	-	25	50
9	PC- IX	EEPC3006	Lab Power System-II	-	-	2	1	25	-	-	25	50
			Total	**18**	**-**	**06**	**21**	**165**	**90**	**60**	**335**	**750**

Semester VI

Semester VI Course				Teaching Scheme			Continuous Evaluation in terms of Marks					
Sr No	Category	Course Code	Course Name	TH	T	PR	Credits	ISE I	ISE II	ISE III	ESE	Total
1	PC-X	EEPC3020	Microcontroller & Applications	3	-	-	3	15	15	10	60	100
2	PC-XI	EEPC3021	Control Systems -II	3	-	-	3	15	15	10	60	100
3	PC XII	EEPC3022	Power Electronics	3	-	-	3	15	15	10	60	100
4	OE-IV			3	-	-	3	15	15	10	60	100
5	HSMC-III			3	-	-	3	15	15	10	60	100
6	ESC	EEES3023	Machine Learning	3	-	-	3	15	15	10	60	100
7	PE- II(Lab)			-	-	2	1	25	-	-	25	50
8	PC-X	EEPC3024	Lab Microcontroller & Applications	-	-	2	1	25	-	-	25	50
9	PC XII	EEPC3025	Lab Power Electronics	-	-	2	1	25	-	-	25	50
10	ESC	EEES3026	Lab Machine Learning	-	-	2	1	25	-	-	25	50
			Total	**18**	**-**	**08**	**22**	**190**	**90**	**60**	**460**	**800**

#Industrial Training will be done after IV, VI semester for which credit will be awarded in VII semester.

ISE I, II are compulsory tests. ISE III will be based on any one of the following components - Surprise Test, Declared Test, MCQ Test, Assignments, PPT presentation, Quiz, Fabrication of working model, etc. However, the course coordinator shall declare the method of evaluation at the beginning of the course.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Teaching and Evaluation Scheme from year 2024-25

Final Year B. Tech. Program in Electrical Engineering

Semester VII

Semester VII Course				Teaching scheme			Continuous Evaluation in terms of Marks					
Sr No	**Category**	**Course Code**	**Course Name**	**TH**	**T**	**PR**	**Credits**	**ISE I**	**ISE II**	**ISE III**	**ESE**	**Total**
1	PC XIII	EEPC4001	Electrical Drives	3	-	-	3	15	15	10	60	100
2	PC XIV	EEPC4002	Power System Protection	3	-	-	3	15	15	10	60	100
3	PC XV	EEPC4003	Digital Signal Processing	3	-	-	3	15	15	10	60	100
4	PE-III			3	-	-	3	15	15	10	60	100
5	OE-V			3	-	-	3	15	15	10	60	100
6	PC XVI	EEPC4004	Lab Electrical Drives	-	-	2	1	25	-	-	25	50
7	PC XIV	EEPC4005	Lab Power System Protection	-	-	2	1	25	-	-	25	50
8	Seminar	EEPC4006				2	1	50	-	-	-	50
9	Project Phase I	EEPC4007		-	-	8	4	50	-	-	50	100
10	# Audit Course		Industrial Training	-	-	-	AC	-	-	-	-	-
11	$ABPDC		Activity- 1	-	-	-	AC	-	-	-	-	-
12	$ABPDC		Activity- 2	-	-	-	AC	-	-	-	-	-
			Total	**15**	**-**	**14**	**22**	**225**	**75**	**50**	**400**	**750**

$ Activity based activities personality development courses are to be performed from 3rd semester to 7th semester.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Semester VIII

(One semester long internship in industry/Research Organisation students**)

Semester VIII Course				Teaching Scheme			Continuous Evaluation in terms of Marks					
Sr No	**Category**	**Course Code**	**Course Name**	**TH**	**T**	**PR**	**Credits**	**ISE I**	**ISE II**	**ISE III**	**ESE**	**Total**
1	PE-IV**			3	-	-	3	15	15	10	60	100
2	PE-V **			3	-	-	3	15	15	10	60	100
3	HSMC-IV**			3	-	-	3	15	15	10	60	100
4	Project Phase II	EEPC4020		-		12	6	75	-	-	75	150
			Total	**9**	**-**	**12**	**15**	**120**	**45**	**30**	**255**	**450**

**To be completed online mode or allied courses from MOOCs by the students who wish to go for one semester long internship in Industry/Research Organization. However, normal track students will complete these courses in offline mode in college.

***ISE I , ISE II** will be compulsory Class Test and ISE III will be based on any one of the following components - Surprise Test, Declared Test, MCQ Test, Assignments, PPT presentation, Quiz, Fabrication of working model etc. However, the course coordinator shall declare a method of evaluation at the beginning of the course.

List of Professional Electives**

Courses	1	2	3	4	5	6
PE I EEPE 3010-3015	Electrical Machine Design EEPE 3010	High Voltage Engineering EEPE 3011	Energy Storage System EEPE 3012	Utilization of Electrical Energy EEPE 3013	Optimization Techniques EEPE 3014	
PE II (LAB) EEPE3031-36		Lab High Voltage Engineering EEPE3032	Lab Renewable Energy Technology EEPE3033		Lab Internet of Things EEPE3034	
PE III EEPE4010-4015	Power Systems Dynamics & Control EEPE4010	HVDC & FACT EEPE4011	Smart Grid Technology EEPE4012	Computer Methods in Power Systems EEPE4013	Nonlinear control EEPE4014	Reliability & Condition Monitoring EEPE4015
PE IV EEPE4021-26	Industrial Electrical Systems EEPE4021	EHVAC Transmission EEPE4022	Electrical Power Distribution system EEPE4023	Energy Conservation & Management EEPE4024	Optimal Control EEPE4025	Energized Irrigation Systems EEPE4026
PE V EEPE4027-32	Power System Planning Operation & Control EEPE4027	Power Quality & Mitigation EEPE4028	Electric Vehicles EEPE4029	Restructured Power Systems EEPE4030	Digital Control Systems EEPE4031	Applications of Embedded systems EEPE4032

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4001: Electrical Drives	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

Course Description: In this curriculum, students will be explored to fundamentals, control and operation of AC & DC drives. They will be also introduced to solar powered & battery powered electrical drives and traction drives. They are expected to identify the scope of electrical drives in industries.

Course Objectives:

The objective of the course is to give exposure to the students of -

1. Fundamental of electrical drives.
2. Control & operation of AC & DC drives.
3. Various industrial applications of AC and DC drives.

Course Outcomes:

The students will be able to

CO1: Describe the fundamentals of electrical drives and solve numerical on it
CO2: Discuss and analyze performance of DC motor drives
CO3: Explain and analyze controlled rectifier fed and chopper fed dc drives
CO4: Explain and analyze induction motor drives and its control
CO5: Discuss and identify industrial applications of electrical drives

Detailed Syllabus

Unit-I	**Fundamentals of Electrical Drives:** Concept of electrical drives, Fundamental torque equation, Speed Torque conventions & multi-quadrant operation, Equivalent value of drive parameters, Components of load torque, Nature & classification of load torque, Calculation of time and energy-loss in transient operations, Steady state stability, Load equalization Modes of operation, Closed loop control, Selection of motor power rating
Unit-II	**DC Motor Drives:** DC motor and their performance, Starting, Braking- Regenerative, Dynamic and Plugging, Transient analysis, Speed control, Transient analysis, Energy losses during transient operations
Unit-III	**Control of DC Drives:** Controlled rectifier circuits, 1-phase full and half controlled rectifier-control, 3-phase full and half controlled rectifier control, Multi quadrant operation of fully-controlled rectifier-fed DC motor, Chopper control of separately excited dc motor, Chopper control of series motor

Unit-IV	**Induction Motor Drives and control:** Analysis and performance of 3-phase induction motors, Starting, Braking- Regenerative, Dynamic and Plugging, Speed control, Voltage source inverter (VSI) and Current source inverter (CSI), Slip power recovery- Static Scherbius drive and Static Kramer drive, Control of 1-phase induction motor
Unit-V	**Industrial Applications:** Solar powered drives, Battery powered vehicles, Important features of Traction drive, Traction motors, SRM, BLDC drives Semiconductor converter controlled traction drives, Other industrial applications

Text Books:

1) G. K. Dubey, "Fundamental of Electrical Drives", Second Edition. Narosa Publishing House, New Delhi, India.
2) M. H. Rashid, "Power Electronics", III Edition (Low Price), Pearson Education Pvt. Ltd. New Delhi, India.
3) B. K. Bose, "Modern Power Electronics and AC Drives", Low Price Edition, Pearson Education Pvt. Ltd. New Delhi, India.
4) R. Krishnan, "Electrical Motor Drives: Modeling, Analysis and Control", Low Price Edition, Prentice Hall of India, New Delhi, India.

Mapping of Course outcomes with program outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1		1	1		2	2	2		2		3	
CO2	3	2	1		1	1		2	2	2		2		3	
CO3	3	2	1		2	1		2	2	2		2		3	
CO4	3	2	1		2	1		2	2	2		2		3	
CO5	3	3	1		1	2		2	2	2		2		3	

1 -Low 2-Medium 3-High

ISE III's Assessment: It will be based on **any ONE** of the following:

1. Multiple Choice Objective Test : 10 Marks
2. Assignments/PPT presentation on allotted topics : 10 Marks
3. Quiz
4. Surprise Test

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**ISE I**	**ISE II**	**ISE III**	**End Semester Examination**
K1	Remember	-	-	-	-
K2	Understand	10	10	04	18
K3	Apply	05	05	04	24
K4	Analyze			02	18
K5	Evaluate			-	-
K6	Create			-	-
Total Marks: 100		**15**	**15**	**10**	**60**

Sample Assessment Table:

Assessment Tool	**K2+K3**	**K2+K3**	**K2+K3**	**K2+K3+K4**	**K2+K3+K4**
	C01	C02	C03	CO4	CO5
ISE I (15 Marks)	7.5	7.5	-	-	-
ISE II (15 Marks)	-	-	7.5	7.5	-
ISE III (10 Marks)	02	02	02	02	02
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by:
V. P. Dhote

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4002: Power System Protection	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

Course description:
This is a one-semester course compulsory to all third year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to introduce & explain

1. The philosophy & technology of protection
2. Construction & working of circuit breakers & fuses
3. Different protection schemes of generators & transformers
4. Different protection schemes of transmission lines & bus bars
5. Modern trends in protection

Course Outcomes:

After completing the course, students will be able to:

CO1	Explain basics of fault clearing process
CO2	Explain arc Interruption phenomenon and working of various circuit breakers & their applications
CO3	Apply differential protection schemes to transformers & generators
CO4	Identify protection schemes to transmission lines & bus bars against different faults
CO5	Explain fundamentals of static & numerical relaying

Detailed Syllabus:

Unit 1	**Introduction** Importance of protection in power systems, Fault clearing process , Desirable qualities of protective relaying, Definitions of terms used in relaying, Protective zones , Primary & back up protection
Unit 2	**Principle of Circuit Interruption** Arc phenomenon, A.C. & D.C. circuit breaking, Arc interruption theories, Transient recovery voltage, Re-striking voltage, Factors affecting TRV, Rate of rise of restriking voltage, Resistance switching, Damping of TRV, Current chopping, Capacitive current breaking, Auto reclosing **Circuit Breakers** Construction, Working principle, Application & comparison of different types of circuit Breakers such as Air Break, Air blast, Minimum Oil Circuit breaker, SF6 & Vacuum Circuit breakers, H.V.D.C. Circuit breakers. Different contactors, Rewirable & H.R.C. fuses MCB's, ELCB's , Introduction to Gas Insulated Substations

Unit 3	**Protection of Transformers and Generators** **Transformer protection**: Percentage differential protection, magnetic inrush current phenomenon, percentage differential relay with harmonic restraint, restricted earth fault protection, incipient faults, Buchholz relay, protection against over-fluxing. **Generator protection**: Stator phase and ground fault protection, protection against unbalanced loading, loss of excitation, loss of prime mover and over speeding.
Unit 4	**Transmission lines & Bus bar protection** Introduction to distance relaying, zones of protection, setting and coordination of distance relays, pilot protection with distance relays, Protection against lightning, insulation coordination, Busbar protection: Different bus bar arrangements, differential protection of busbar, high impedance differential relay
Unit 5	**Basics of Static & Numerical relaying** Comparison of static and electro-mechanical relays, two input amplitude and phase comparators and their duality, Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays

Text and Reference Books

1. C. Russul Mason, "Art & Science of Protective Relaying ", John Wiley & Sons
2. Sunil S. Rao, "Switchgear Protection & Power Systems", Khanna Publishers, Fifth edition
3. Y. G. Paithankar S. R. Bhide , "Fundamentals of Power Systems Protection", PHI of India
4. Madhav Rao, "Solid state protective relaying", Tata McGraw Hill
5. M. S. Naidu," Gas Insulated Substations"- IK International Publishing House.1

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1	1		1	1	2	1	2		2	3	1	1
CO2	3	2	1	1		1	1	2	1	2		2	3		
CO3	3	2	1	1		1	1	2	1	2		2	3		
CO4	3	2	1	1		1	1	2	1	2		2	3		
CO5	3	2	1	1		1	1	2	1	2		2	3	2	2

1 - Low 2 – Medium 3 – High

ISE III Assessment: Teachers Assessment of 10 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	ISE I	ISE II	ISE III Assignment	End Semester Examination
K1	Remember	5	5		10
K2	Understand	5	5	5	20
K3	Apply	5	5	5	30
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment table:

Assessment Tool	K1+K2+ K3	K1+K2+ K3	K1+ K2	K1+K3	K2
	CO1	CO2	CO3	CO4	CO5
ISE I (15 Marks)	7.5	7.5			
ISE II (15 Marks)			7.5	7.5	
ISE III (10 Marks)				5	5
ESE Assessment (60 Marks)	10	20	10	10	10

Teaching Strategies:

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

Special Instructions if any: Nil

Designed by
Dr. S. P. Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4003: Digital Signal Processing	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

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

Course Objectives:

The objectives of the course are to give exposure of

1. Introduce the basic concepts and techniques for processing signals on a computer.
2. Be familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.
3. Emphasizes intuitive understanding and practical implementations of the theoretical concepts.

Course Outcomes:

After completing the course, students will able to:

CO1	Characterize and analyze various discrete-time signals analytically and visualize them in the time domain.
CO2	Transform and analyze discrete-time signals implications of the properties of systems and signals.
CO3	Understand parameters of digital filter design for continuous time signals
CO4	Specify and design digital filters for continuous time signals
CO5	Apply filter design for real time signals

Detailed Syllabus:

Unit 1	**Signals and Signal Processing:** Characterization and Classification of Signals, Typical Signal Processing Operations, Examples of Typical Signals, Typical Signal Processing Applications, Why Digital Signal Processing? **Discrete-Time Signals and Systems in the Time-Domain:** Discrete-Time Signals, Typical Sequences and Sequence Representation, the Sampling Process, Discrete-Time Systems, Time-Domain Characterization of LTI Discrete-Time Systems, Finite-Dimensional LTI Discrete-Time Systems, Correlation of Signals, Random Signals

Unit 2	**Transform-Domain Representations of Discrete-Time Signals** The Discrete-Time Fourier Transform, Discrete Fourier Transform, Relation Between the DTFT and the DFT, and Their Inverses, Discrete Fourier Transform Properties, Computation of the DFT of Real, Sequences, Linear Convolution Using the DFT, The z-Transform, Region of Convergence of a Rational z-Transform, The Inverse z-Transform, z-Transform Properties, Transform-Domain Representations of Random Signals **LTI Discrete-Time Systems in the Transform-Domain** Finite-Dimensional LTI Discrete-Time Systems, The Frequency Response, The Transfer Function, Types of Transfer Functions, Simple Digital Filters, All-pass Transfer Function, Minimum-Phase and Maximum-Phase Transfer Functions, Complementary Transfer Functions, Inverse Systems, System Identification, Digital Two-Pairs, Algebraic Stability Test, Discrete-Time Processing of Random Signals, Matched Filter
Unit 3	**Digital Processing of Continuous-Time Signals** Introduction, Sampling of Continuous-Time Signals, Sampling of Band pass Signals, Analog Low pass Filter Design, Design of Analog High pass, Band pass, and Band stop Filters, Anti-Aliasing Filter, Design of Sample-and-Hold Circuit, Analog-to-Digital Converter, Digital-to-Analog Converter, Reconstruction Filter Design, Effect of Sample-and-Hold Operation.
Unit 4	**Digital Filter Structures** Block Diagram Representation, Equivalent Structures, Basic FIR Digital Filter Structures, Basic IIR Filter Structures, Realization of Basic Structures using MATLAB, All pass Filters, Tunable IIR Digital Filters, IIR Tapped Cascaded Lattice Structures, FIR Cascaded Lattice Structures, Parallel All pass Realization of IIR Transfer Functions, Digital Sine-Cosine Generator
Unit 5	**Digital Filter Design** Preliminary Considerations, Bilinear Transform Method of IIR Filter Design, Design of Low pass IIR Digital Filters, Design of High pass, Band pass, and Band stop IIR Digital Filters, Spectral Transformations of IIR Filters, FIR Filter Design Based on Windowed Fourier Series, Computer-Aided Design of Digital Filters, Design of FIR Filters with Least-Mean-Square Error, Digital Filter Design Using MATLAB **Applications of Digital Signal Processing** Spectral Analysis of Sinusoidal Signals, Spectral Analysis of Nonstationary Signals, Spectral Analysis of Random Signals

Text Books:

1. R. Babu. , “Digital Signal Processing”, Laxmi Publication Ltd.
2. A. Ambardar, “Digital Signal Processing: A Modern Introduction”, Penram International Publishing (India) Pvt. Ltd.

Reference Books:

1. Proakis, “Digital Signal Processing”, Pearson Education Limited
2. Oppenheim and Schafer, “Discrete-Time Signal Processing”, Prentice-Hall, 1989.
3. Rabiner, R. Lawrence, “Theory and Application of Digital Signal Processing”, Gold, Bernard, Prentice-Hall

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	2	1	3		2	2			1	1	1	2	1
CO2	3	3	2	1	3		2	2			1	1	1	2	1
CO3	3	3	2	1	3		2	2	1		1	1	1	2	1
CO4	3	2	2	1	3	1	1	2	1			1	1	2	1
CO5	3	1	2	1	3	1	1	2	1			1	1	2	1

1 – Low 2 – Medium 3 High

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

1. Assignments based on Numerical from exercise (unsolved problems from Textbooks).
2. Objective type test.
3. Solving network problems by MATLAB. solution

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test I**	**Test II**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5	5	4	15
K2	Understand	5	5	2	20
K3	Apply	5	5	4	25
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+k3+K4
	C01	C02	C03	CO4
Class Test (30 Marks)	10	05	05	10
Teachers Assessment (10 Marks)	4	2	2	2
ESE Assessment (60 Marks)	24	12	12	12

Special Instructions if any: NIL

Designed by
Dr. N. J. Phadkule

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4004: Lab Electrical Drives	
Teaching Scheme Practical : 2 Hrs/Week Total Credits : 1	**Examination Scheme** Term Work : 25 Marks Practical Examination : 25 Marks

Course Objectives:

The objective of the course is to give exposure and hands on training to the students to

1. Operate and carry out performance analysis of DC motor drives
2. Operate and carry out performance analysis of AC motor drives

Course Outcomes:

The students will be able to

CO1: Demonstrate basic operations of AC and DC drives
CO2: Use AC & DC drives
CO3: Analyze performance of AC and DC drives
CO4: Record the operations and write technical reports
CO5: Work individually and in a team effectively

List of Experiments:

Term work shall consist of record of minimum eight experiments based on performance, software modeling and study from the following list

Sr. No.	Details
1	Three experiments based on study and/ or modeling and simulation of electrical drives using MATLAB/SIMULINK or any electrical software
2	Direction control and speed control of DC motor drives
3	Starting, stopping and accelerating & decelerating time adjustments of DC motor drives
4	Braking and protection of DC motor drives
5	Performance characteristics of DC motor drives using Jones Chopper
6	Starting, stopping and accelerating & decelerating time adjustments of AC motor drives
7	Torque-speed characteristics of AC motor
8	V/F ratio control of AC motor drive
9	Speed control of 3-phase slip ring induction motor
10	Study of industrial applications of AC motor drives
11	Study of industrial applications of DC motor drives

Term Work:

The term work shall consist of performance of above enlisted experiments and submission of technical write up. The term work will be assessed by the Course Coordinator.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Practical Examination:

The practical examination will comprise of performance of any one experiment and viva voce on the complete curriculum of the course. The internal and external examiners appointed by the Controller of Examination will assess the performance of the student.

Mapping of Course outcomes with program outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3									1		2		3	
CO2	3		1	2	3			2		2		2		3	
CO3	3	3	1	2	3			2		2		2		3	
CO4								2		2		2		3	
CO5								2	3	2		2		3	

1- Low 2-Medium 3-High

Designed by
Prof. V. P. Dhote

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4005: Lab Power System Protection	
Teaching Scheme Practical : 2 Hrs/Week Total Credits : 1	**Examination Scheme** Term Work : 25 Marks Practical Examination : 25 Marks

Course Objectives

The objectives of the course are to-

1. Learn fundamentals of relay operation
2. Learn working & application of different switchgears
3. Learn different protection schemes for the protection of power system equipments
4. Learn recent developments in relaying

Course Outcomes:

After completion of this course students will be able to

CO 1. Do the relay settings & plot the characteristics of relay
CO 2. Explain working of circuit breakers
CO 3. Apply different protection schemes
CO 4. Know basics of static and numerical relay

List of the Experiments:

Term work shall consist of minimum eight experiments from the following:

Sr. No.	Name of the Experiments
1	Study & use switchgear testing kit.
2	Plot Characteristics of rewirable HRC fuse.
3	Plot Characteristics of over current relay.
4	Study Distance protection of transmission lines.
5	Study Biased & Unbiased differential protection of transformer
6	Study Differential protection of alternators.
7	Study of vacuum circuit breakers.
8	Study of Numerical Relay.
9	Study of Air Circuit Breakers.
10	Study of Bucholz, Relay
11	Study of MCB.
12	Study of static relay.
13	Study of protection of 3-phase Induction Motor against various faults.
14	Simulation of sine and cosine type comparators in MATLAB/Simulink.
15	Visit report on protection schemes in substation.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Term work:

The term work shall consist of submitting a file for minimum eight experiments performed with neatly written records of the study, programs & observations with results.

The term work will be assessed by the course coordinator

Mapping of Course outcome with Program Outcomes:

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1	2	1	3	2	2	1	2	2	2	3	2	
CO2	3	2	1	2	1	3	2	2	1	2	2	2	3	2	
CO3	3	2	1	2	1	3	2	2	1	2	2	2	3	2	
CO4	3	2	1	2	2	3	2	2	1	2	2	2	3	2	1

1 - Low 2 – Medium 3– High

Assessment Pattern:

Assessment Pattern Level No.	**Skill Level**	**Term Work**	**Practical Examination & viva voce**
S1	Imitation	10	10
S2	Manipulation	05	05
S3	Precision	10	10
S4	Articulation		
55	Naturalization		
Total		25	25

Details	**Term Work**	**Practical Examination & viva voce**
Preparation Program/Model(S1)	05	
Conduct of Experiment Execution of program/Model (S2)	05	5
Observation and Analysis of Results (S3)	05	5
Record (S2)	05	5
Presentation/ Viva-Voce (S3)	05	10
Total	**25**	**25**

Assessment Table :

Assessment Tool	**S1+S2+S3**	**S1+S2+S3**	**S1+S2+S3**	**S1+S2+S3**
	C01	C02	CO3	CO4
Term Work (25 Marks)	05	05	05	05

Designed by Dr. S. P. Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4006: Project Phase-I	
Teaching Scheme Practical: 8 Hrs/Week Credit: 4	**Examination Scheme** ISE I/ Term Work : 50 Marks Practical viva : 50 Marks Total : 100 Marks

Term Work

Projects should be based on Software based simulation/Case study/ Analysis/ Design Methodology/ Hardware/ Industry based projects. It is expected that the broad area project shall be finalized by the student at the beginning of the semester. Approximately 50% work shall be completed by the end of semester VII. Students shall give the presentation on the project and shall submit the progress report in the following format.

i. Title
ii. Abstract
iii. Introduction
iv. Project objectives
v. Literature survey
vi. Work to be completed
vii. Expected results and conclusion
viii. References

EEPC 4007: Industrial Training(Audit Course)	
Teaching Scheme	**Examination Scheme**
Practical : 0Hr/Week	Term Work : Nil
Total Credits : 0	Total : Nil

1. Students will undergo Internship /Industrial training for four to six weeks with a minimum of two weeks in one attempt.
2. Students will present a seminar on Internship /Industrial training.
3. Students will submit reports on Internship /Industrial training.

Syllabus for Professional Electives III

EEPE 4010: Power Systems Dynamics & Control	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks ESE Exam :60 Marks

Course description:

This Course deals with various Stability conditions of the power system, causes for instability and methods of stability enhancement. Various excitation control methods, Reactive power compensation and load frequency control is also dealt with.

Course Objectives:

The objectives of the course are to-

1. Explain concepts of power system stability to students.
2. Describe transient stability and methods of analysis.
3. Enumerate excitation systems for students.
4. Introduce the concept of reactive power and voltage control.
5. Explain optimal operation of generating units & grid management.

Course Outcomes:

After completing the course, students will able to-

CO1	Describe stability conditions of power systems.
CO2	Determine transient stability under various fault conditions.
CO3	Employ excitation methods
CO4	List reactive power and voltage control methods.
CO5	Find the optimum unit commitment for a power system.

Detailed Syllabus:

Unit I	**Power system Stability** Brief review of synchronous machine equations and parameters, concept of steady state, transient and dynamic stability , Modeling of synchronous machine, the stability problem, power angle equation, node elimination techniques ,Steady state stability limit, methods to determine steady state stability limit- Clarke diagram etc., methods of improvement
Unit II	**Transient stability analysis** Swing equation , point by point solution of the swing equation, one machine connected to infinite bus, critical clearing angle and time; equal area criterion for stability and its application to one machine infinite bus and two finite machines problems, concept of multi-machine system; effect of type of fault, grounding, reclosing on transient stability limit , methods of improvement

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Unit III	**Excitation Systems:** Excitation System requirements, Elements of an excitation system Types of excitation systems. Improvement of stability: Transient stability enhancement, small signal stability enhancement.
Unit IV	**Control of voltage and reactive power** Necessity, Various Methods, Load Frequency Control: Load frequency problem, speed governing system, automatic voltage control
Unit V	**Optimal system operation** System constraints, economic load sharing of units in power stations and in interconnection; incremental fuel cost method, Grid Management

Text and Reference Books:

W.D. Stevenson, "Elements of Power Systems Analysis", McGraw Hill
Wadhawa C.L, "Electrical Power System", Wiley Eastern ltd.
I.J. Nagrath and D.P. Kothari, "Modern Power System Analysis", Tata McGraw-Hill
HadiSaadat, " Power System Analysis", Tata McGraw-Hill
O.I. Elgerd, "Electric Energy Systems Theory" , Tata McGraw-Hill
Stevenson W.D. and Grainger J.J., "Power System Analysis", McGraw-Hill
PrabhaKundur , "Power System Stability And Control", Tata McGraw-Hill

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 13	PSO 14	PSO 15
CO1	3	2				1			1	1		1	3		
CO2	3	2				1			1	1		1	3		
CO3	3	2				1			1	1		1	3		
CO4	3	2				1			1	1		1	3		
CO5	3	2				1			1	1		1	3		

1-Low, 2-Medium 3- High

ISE III Assessment: Teachers Assessment of 10 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:

Sample Assessment Pattern Level No.	**Knowledge Level**	**ISE I**	**ISE II**	**ISE III**	**End Semester Examination**
K1	Remember	5	5		10
K2	Understand	5	5	5	30
K3	Apply	5	5	5	20
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+	K2+ K3	K2+ K3	K2	K2+ K3
	CO1	CO2	CO3	CO4	CO5
Class Test I (15 Marks)	7.5	7.5			
Class Test II (15 Marks)			7.5	7.5	
Teachers Assessment (10 Marks)				5	5
ESE Assessment (60 Marks)	10	20	10	10	10

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

Special Instructions if any: Nil

Designed by
Dr. V. A. Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4011: HVDC & FACT	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

Course Objectives:

The objectives of the course are to-

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

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

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

Detailed Syllabus:

Unit-1	**Introduction:** Comparison of AC and DC transmission systems, application of DC transmission, types of DC links, layout of a HVDC converter station. HVDC converters, pulse number, analysis of Gratez circuit with and without overlap, converter bridge characteristics, equivalent circuits or rectifier and inverter configurations of twelve pulse converters
Unit-2	**Converter & HVDC System Control:** Principles of DC Link Control, Converters Control Characteristics, Control hierarchy, firing angle control, current and extinction angle control, starting and stopping of DC link.
Unit-3	**Harmonics, Filters and Reactive Power Control:** Introduction, generation of harmonics, AC and DC filters. Reactive Power Requirements in steady state, sources of reactive power, static VAR systems.
Unit-4	**Introduction to FACTS:** Flow of power in AC parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers. **Static Shunt Compensators:** Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM.
Unit-5	**Static Series Compensators**: Objectives of series compensation, variable impedance type-thruster switched series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC)-power angle characteristics-basic operating control schemes.

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Text Books:

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

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	P O 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2											2		2
CO2	3	2											2		2
CO3	3	2		1									2		2
CO4	3	2		1									2		2
CO5	3	1											2		2

1- Low 2- Medium 3- High

ISE III Assessment: Assessments will be based on any two following components -

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

Sample Assessment Pattern:

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

ISE III Assessment: Teachers Assessment of 10 marks is based on one of the following ,

1. Assignments : 10 Marks
2. MCQ test. : 10 Marks
3. Presentation on recent topics related to HVDC :10 Marks

Sample Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	Class Test I	Class Test II	Teachers Assessment/ Assignment	End Semester Examination
K1	Remember	5	5	2	12
K2	Understand	5	5	4	24
K3	Apply	5	5	4	24
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K1+K2+K3	K1+K2+K3	K1+K2+K3
	C01	C02	C03	CO4	CO5
ISE I (15 Marks)	7.5	7.5	----	-----	---
ISE II (15 Marks)	----	-----	7.5	7.5	----
ISE III Assessment (10 Marks)	2	2	2	2	2
ESE Assessment (60 Marks)	12	12	12	12	12

Special Instructions if any: NIL

Designed by
Prof. S. S. Mopari

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4012 Smart Grid Technology	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :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	Explain fundamentals of smart grid
CO2	Describe different smart grid technologies
CO3	Explain the concept of micro grids and distributed energy resources
CO4	Identify the power quality issues in Smart grid
CO5	Compare different communication technologies for Smart Grid

Detailed Syllabus:

Unit 1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid
Unit 2	**Smart Grid Technologies:** Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers. Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit
Unit 3	**Micro grids and Distributed Energy Resources:** Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar Cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources.

Unit 4	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.
Unit 5	**Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

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, KithsiriLiyanage, 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)

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1				2	2	3	2	2		2	3		
CO2	3	1				2	2	3	2	2		2	3	2	2
CO3	3	1				2	2	3	2	2		2	3	2	2
CO4	3	1				2	2	3	2	2		2	3	1	
CO5	3	1				2	2	3	2	2		2	3	2	2

1 – Low 2 – Medium 3 – High

ISE III Assessment: Teachers Assessment of 10 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 I	Class Test II	Teachers Assessment/ Assignment	End Semester Examination
K1	Remember	5	10	5	30
K2	Understand	10	5	5	30
K3	Apply				
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2	K1+K2	K1+K2	K1	K1+K2
	C01	C02	C03	CO4	CO5
Class Test I (15 Marks)	7.5	7.5			
Class Test II (15 Marks)			7.5	7.5	
Teachers Assessment (10 Marks)				5	5
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Dr. S. P. Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4013 Computer Methods in Power Systems	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

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

Course Objectives:

The objectives of the course are to:

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

Course Outcomes:

After completing the course, students will able to:

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

Detailed Syllabus:

Unit 1	**Network Modeling:** System graph, loop, cut set and Incidence matrices, Primitive network and matrix, Formation of various network matrices by singular transformation. Bus Impedance Algorithm: Singular transformation, Direct inspection, Building Block algorithm for bus impedance matrix, Addition of links, addition of branches, (considering mutual coupling), modification of bus impedance matrix for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron's reduction)
Unit 2	**Analysis of symmetrical & unsymmetrical Faults:** Shunt Faults, Shunt Fault Calculations, Series Faults, Sequence Impedances of Transmission Lines, Sequence Capacitance of Transmission Lines, Sequence Impedance of Synchronous and Induction Machines, Transformers, Three Winding Transformers
Unit 3	**Computer Solution of Power Flow Problem:** Solution using Admittance and Impedance Matrix, Comparison of Admittance and Impedance Matrix Techniques. Power-Flow Problem, Gauss-Seidel, Newton-Raphson Methods, Power Flow Studies in System Design and Operation, Decoupled Power Flow Method
Unit 4	**State Estimation:** Method of least squares ,statistics , errors, estimates, test for bad data, structure and formation of Hessian matrix, power system state estimation

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

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

Text and Reference Books

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

ISE III Assessment:

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

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

Sample Assessment Pattern:

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

Sample Assessment table:

Assessment Tool	K2+K3+K4	K2+K3	K2+K3	K2+K3+K4	K2+K3
	C01	C02	C03	CO4	CO5
ISE I (15 Marks)	10	05			
ISE II (15 Marks)			10	05	
ISE III (10 Marks)					10
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by Dr. V. A. Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4014: Nonlinear Control	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

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

CO1	Understand the behavioral properties of nonlinear control systems
CO2	Analyze stability analysis using harmonic linearization method
CO3	Analyze stability analysis using phase plane technique
CO4	Evaluate stability of nonlinear systems using Lyapunov design
CO5	Apply feedback linearization methods for nonlinear systems

Detailed Syllabus

Unit-I	**Introduction and classical techniques:** Review of mathematical preliminaries on point-set topology, normed spaces, Lipschitz continuity, existence and uniqueness of solution of ODE's. Characteristics of nonlinear systems, classification of equilibrium points, limit cycles
Unit-II	**Harmonic Linearization and Describing Function Method:** Harmonic linearization, filter hypothesis, describing function of standard nonlinearities, study of limit cycles (amplitude and frequency) using SIDF, Dual Input Describing function, study of sub- harmonic oscillations, correction on describing functions.
Unit- III	**Phase plane analysis:** Analysis of systems with piecewise constant inputs using phase plane analysis, perturbation techniques, periodic orbits, stability of periodic solutions, singular perturbation model, slow and fast manifolds. Phase-plane portrait, positively invariant sets and classification of equilibrium points.
Unit IV	**Lyapunov Stability and Design:** Stability of Nonlinear Systems, Lyapunov stability, local stability, local linearization and stability in the small, Direct method of Lyapunov, generation of Lyapunov function for linear and nonlinear systems, variable gradient method. Robust stabilization, Nonlinear Damping, backstepping, sliding mode control, adaptive control
Unit V	**Feedback Control and Feedback Stabilization:** Analysis of feedback systems, Circle Criterion, Popov Criterion, simultaneous Lyapunov functions, Feedback linearization, stabilization, regulation via integral control, gain scheduling, input state linearization, input output linearization, state feedback control, stabilization, tracking, integral control

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Text / References Books:

1. Nonlinear Control systems, A Isidori, Springer verlag, 2013, 3rd Edition.
2. Nonlinear Systems, Hassan K. Khalil, Pearson, 2001, 3rd Edition.
3. Applied Nonlinear Control, Slotine& W. LI, Pearson, 1991, 1st Edition.
4. Nonlinear Dynamic Control Systems, H. Nijmeijer & A.J. Vander Schaft, Springer, 2016, 1st Edition.
5. Introduction to Applied Nonlinear Dynamical Systems and chaos, S. Wiggins, Springer, 2010, 2nd Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106162/

Mapping Of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 13	PSO 14	PSO 15
CO1	3	2				1			1	1		1		2	
CO2	3	2				1			1	1		1		2	
CO3	3	2				1			1	1		1		2	
CO4	3	2				1			1	1		1		2	
CO5	3	2				1			1	1		1		2	

1-Low, 2-Medium 3- High

ISE III Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the 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:

Sample Assessment Pattern Level No.	**Knowledge Level**	**ISE I**	**ISE II**	**ISE III**	**End Semester Examination**
K1	Remember	5	5		10
K2	Understand	5	5	5	30
K3	Apply	5	5	5	20
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+	K2+ K3	K2+ K3	K2	K2+ K3
	CO1	CO2	CO3	CO4	CO5
ISE I (15 Marks)	7.5	7.5			
ISE II (15 Marks)			7.5	7.5	
ISE III (10 Marks)				5	5
ESE Assessment (60 Marks)	10	20	10	10	10

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. Sandhya Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4015: Reliability & Condition Monitoring	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

Course Description:

Reliability and Condition Monitoring is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. Know engineering system monitoring and fault diagnosis and explain 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 focus 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 a model for improvement in the 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 gasses, 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

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

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 equipment, 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, IEEE Power and Energy Series, 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

Mapping of Course outcome with Program Outcomes (Electrical Engineering)

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1	1	1					2	2	
CO2	3	1				1	1	1					2	2	
CO3	3	1											2	2	
CO4	3	1	1			1		1					2	2	
CO5	3	1						1					2	2	

1- Low 2-Medium 3-High

ISE III Assessment: Teachers Assessment of 10 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	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	5	5	5	15
K2	Understand	5	5	5	25
K3	Apply	5	5		20
K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+ K3	K1+K2+K3	K1+ K2	K1+K2	K1+K3
	CO1	CO2	CO3	CO4	CO5
ISE I (15 Marks)	10	05	10		
ISE II (15 Marks)			10	05	
ISE III Assessment (10 Marks)				5	5
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. S. M. Shinde

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Semester II

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPC 4020: Project Phase-II	
Teaching Scheme Practical : 12 Hrs/Week Total Credits : 6	**Examination Scheme** Term Work : 75 Marks Practical work : 75 Marks Total : 150 Marks

Term Work:

1. Students will demonstrate the project and give a presentation on the project.
2. Project report contains a minimum of 50 pages and it will have one section on the impact of proposed ideas/work on the environment and society.

Course Description: The student shall collect, review, compile, comprehend, present research literature and identify the problem for the project in the field of Electrical Engineering. Students will give a presentation on work done by them on any topic of the recent technology which may include some simulation carried out by the student.

Course Objectives:

- To understand the "Product Development Process" including budgeting through 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 Project work carried out

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

- Understand, plan and execute a Project
- Implement electronic hardware by learning PCB artwork design, soldering techniques, testing, and troubleshooting etc.
- Prepare a technical report based on the project
- Deliver technical seminar based on the 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 Project 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., the candidate shall define the problem for the project.

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

Evaluation of Project Ph II: It consists of two parts.

Part-I: Evaluation for 25 Marks: A mid-term evaluations for 25 marks out of 50 marks shall be done as per the schedule given in the institute academic calendar. Students should prepare a 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. The panel of examiner will assess the contents and presentation and give the suggestions, if any and assign the marks. In this phase students are expected to collect and present substantial literature.

Part-II: Evaluation for 50 Marks: Students 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 assign the marks. In this phase the students are 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- 75 Marks	25	25	25
Viva-voce Assessment-75 Marks	25	25	25

Table 3: Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Term Work Assessment**	**Viva-voce Examination**
K1	Remember		
K2	Understand	20	20
K3	Apply	20	20
K4	Analyze	20	20
K5	Evaluate	15	15
K6	Create	--	--
Total Marks		**75**	**75**

Syllabus for Professional Electives IV, V

EEPE 4021 Industrial Electrical Systems	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End-Semester Exam :60 Marks

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

1. design the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
2. design and estimate electrical systems.
3. interpret Indian electrical rules.
4. design motor control circuits.

Course Outcomes:

The students will be able to

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

CO1	design and estimate electrical systems.
CO2	design the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
CO3	interpret Indian electrical rules.
CO4	understand design of overhead transmission lines
CO5	design motor control circuits.

Detailed Syllabus:

Unit I	**Electrical Symbols and Standards** Need of electrical symbols, list of symbols, electrical diagrams, methods of representations for wiring diagram Light and Fan Circuits, Alarm Circuits, Introduction to simple light and fan circuits, System of connection of supply and accessories, Introduction to simple alarm circuits with and without relay, Schematic and wiring diagrams for alarm and signal circuits without relays, Alarm circuit with relays, Design of Small Transformer and Chokes, Theory of transformer design, Design and making of a small transformer, Design of Chokes.
Unit II	**Design Considerations of Electrical Installations** Design and Drawing of Panel Boards, Introduction, Design conditions, standard sizes of boards, Electric supply systems, Three phase four wire distribution systems, Protection of electric installation against overload, short circuit and earth fault, Earthing, General requirements and testing of electrical installations, Indian Electricity rules, Neutral and earth wire, Types of loads, Systems of wiring, Service connections, Service mains, Sub circuits, Location of outlets, Location of control switches, Location of main board and distribution boards, Load assessment, Guidelines for installation of fittings, Permissible voltage drops and sizes of wires, Estimating and costing of electrical installations

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Unit III	**Electrical Installations** Electrical Installations for different types of buildings and small industries, Electrical installations for residential buildings – estimating and costing of material, Electrical installations for commercial buildings, Electrical installations for small industries
Unit IV	**Overhead and Underground Transmission and Distribution Lines Supports for transmission lines:** Distribution Lines – materials used Underground cables, Mechanical design of overhead lines, Design of underground cables, Quantity estimation, Substations, Types of substations, Outdoor substations – pole mounted type Indoor substations – flour mounted type.
Unit V	**Motor Control Circuits** Starting of 3-phase squirrel cage induction motor, Starting of multi-speed squirrel cage motors, Starting of wound rotor motor, Starting of synchronous motors, Stopping of motors, Contactor control circuit components, Basic control circuits, Motor protection Schematic and wiring diagrams for motor control circuits.

Text Books/Reference Book:

1. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 6th edition, 2009.

2. K. B. Raina and S. K. Bhattacharya, "Electrical Design, Estimating & Costing", New age International Publisher, Reprint, 2009.

3. Surjeet Singh, "Electrical estimating and costing", Dhanpat Rai and Co., Second edition, 2001, reprint 2008.

4. Web site for IS Standards. • Technical manual of Switchgear Industry.

Mapping of Course outcomes with program outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	2		1	1		2	2	2		2		3	
CO2	3	2	2		1	1		2	2	2		2		3	
CO3	3	2	2		2	1		2	2	2		2		3	
CO4	3	2	2		2	1		2	2	2		2		3	
CO5	3	2	2		2	1		2	2	2		2		3	

1 –Low 2 – Medium 3 –High

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

1. Assignment, 2. MCQ

Sample Assessment Pattern:

Level No.	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	5	5	4	14
K2	Understand	5	5	2	12
K3	Apply	5	5	4	14
K4	Analyze				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+k3+K4	K2+k3+K4
	C01	C02	C03	CO4	CO5
ISE I, ISE II (30 Marks)	06	06	06	06	06
ISE III (10 Marks)	2	2	2	2	2
ESE (60 Marks)	12	12	12	12	12

Special Instructions If Any: NIL

Designed by
Dr. S. M. Shinde

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE4022: EHV AC Transmission System (Professional Elective IV)	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	ISE I : 15 Marks
Tutorial : 00	ISE II : 15 Marks
Total Credits : 03	ISE III : 10 Marks
	E SE Exam : 60 Marks

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

Course Objectives: The objectives of the course are to

1. Understand the basic aspects of A.C. power transmission
2. Learn Reflection and Refraction of Traveling Waves
3. Learn various causes for over voltages**.**
4. Understand reactive power flow & voltage stability in Power Systems.
5. Learn Power Transfer at Voltage Stability Limit of EHV Lines

Course Outcomes:

After completing the course, students will able to:

CO1	Describe basic aspects of A.C. Power Transmission & evaluate surface voltage gradient on conductors
CO2	Explain fundamentals of Traveling Waves and Standing Waves
CO3	Elaborate the causes of over voltages in EHV systems
CO4	Discuss reactive power flow & stability conditions
CO5	Explain the conditions for power transfer at voltage stability limit of EHV Lines

Detailed Syllabus:

Unit-1	**Basic Aspects of A.C. Power Transmission:** line trends and preliminary aspects of A.C. Power Transmission, Power-Handling Capacity and Line Loss, standard transmission voltages, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference.
Unit-2	**Traveling Waves and Standing Waves:** Line Energization with Trapped-Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection Lightning & Lightning Protection, Insulation Coordination Based on Lightning
Unit-3	**Over Voltages in EHV Systems**: Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Control of Power Frequency Voltages and switching Over Voltages, Power Circle Diagram.
Unit-4	**Reactive Power Flow and Voltage Stability in Power Systems:** Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post-Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability
Unit-5	**Power Transfer at Voltage Stability Limit of EHV Lines:** Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Text and Reference Books:

1. A. Chakrabarti, D.P.Kothari, A.K. Mukhopadhyay ,"Performance, operation & control of EHV power transmission system " , wheeler publications
2. Rakosh Das Begamudre,"Extra high-voltage A.C. transmission Engineering" New Age International Pvt. Ltd.
3. S.Rao,"EHVAC and HVDC Transmission Engineering & Practice" , Khanna Publications

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Po 13	PO 14	PO 15
CO1	3	2				2	2	2	1	2		2	3	1	
CO2	3	2				2	2	2	1	2		2	3	1	
CO3	3	1				2	2	2	1	2		2	3	1	
CO4	3	1				2	2	2	1	2		2	3	1	
CO5	3	2				2	2	2	1	2		2	3	1	

1 – Low 2 – Medium 3 – High

Teacher's Assessment: Teachers Assessment of 10 marks is based on **attendance** of the student and one of the / or combination of few of following.

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

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		20
K2	Understand	15	5	30
K3	Apply	10	5	10
K4	Analyze			
K5	Evaluate			
K6	Create			
Total Marks 100		30	10	60

Sample Assessment table:

Assessment Tool	K1+K2+K3	K1+K2	K1+K2 +K3	K1+K2	K1+K2
	C01	C02	C03	CO4	CO5
Class Test (30 Marks)	10	5	10	05	
Teachers Assessment (10 Marks)	02	02	02	02	02
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Dr. V. A. Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4023: Electrical Power Distribution Systems (Professional Elective IV)	
Teaching Scheme	**Examination Scheme**
Lectures : 3 Hrs./Week	ISE I : 15 Marks
Tutorial : 00	ISE II : 15 Marks
Total Credits : 03	ISE III : 10 Marks
	End Semester Exam : 60 Marks

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

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

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

Course Outcomes:

After completing the course, students will able to:

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

Detailed Syllabus:

Unit I	**Introduction and General concepts** Introduction to Distribution Systems, Load modeling and Characteristics- Coincidence factor, Contribution factor, loss factor, Relationship between the load factor and loss factor, Classification and characteristics of loads -Residential, commercial, Agricultural and Industrial. Distribution System Planning
Unit II	**Distribution Feeders and Substations** **Distribution Feeders:** Design Considerations of distribution feeders: Radial, loop and network types of primary feeders, Voltage levels, Feeder loading, general circuit constants (A, B, C, D) to radial feeders, Basic design practice of the secondary distribution system. **Substations:** Location of substations, Rating of distribution substation, Service area within primary feeders- Benefits and methods of optimal location of substations.
Unit III	**Distribution System Analysis:** **Voltage drop and power–loss calculations**: Derivation for voltage drop and power loss in lines-Uniformly distributed loads and non-uniformly distributed loads -Numerical problems-Three phase balanced primary lines. Power Flow Analysis of balanced distribution system
Unit IV	**Protective Devices & Coordination:** Objectives of Distribution system protection, Types of common faults and procedure for fault calculation **Protective devices:** Principle of operation of fuses, circuit reclosers and line sectionalizers and circuit breakers. **Coordination of Protective device**s: General coordination procedure
Unit V	**Voltage control and Power factor improvement:** **Voltage Control:** Equipment for voltage control, Effect of series capacitors, Effect of AVB/AVR - Line drop compensation, Numerical problems. **Power factor improvement:** Capacitive compensation for power factor control, Different types of power capacitors, shunt and series capacitors, Effect of shunt capacitors (Fixed and switched), Power factor correction, Capacitor allocation, Economic justification, Procedure to determine the best capacitor location, Numerical problems.

Text/ Reference Books

1. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers.
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4th edition, 1997.
3. Distribution System Modeling and Analysis by William H Kersting- CRC Press,Taylor and Francis Group 3rd Edition, 2012
4. 2. Turan Gonen, Electric Power Distribution System Engineering, CRC Press, 3rd Edition 2014.

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	P O 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O 2	PS O 3
CO1	3	1			1	1			1			1		1	2
CO2	3	2	1		1	1		1	1		1	1		1	2
CO3	3	2	1	1	1	1		1	1	1		1		1	2
CO4	3	2	2		1	1	1	1	1	1	1	1		1	2
CO5	3	2	1	2	1				1			1		1	2

1 –Low 2 – Medium 3 –High

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

1. Assignment, 2. MCQ

Sample Assessment Pattern:

Level No.	**Knowledge Level**	**ISE I**	**ISE II**	**ISE III**	**End Semester Examination**
K1	Remember	5	5	4	14
K2	Understand	5	5	2	12
K3	Apply	5	5	4	14
K4	Analyze				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+k3+K4	K2+k3+K4
	C01	C02	C03	CO4	CO5
ISE I, ISE II (30 Marks)	06	06	06	06	06
ISE III (10 Marks)	2	2	2	2	2
ESE (60 Marks)	12	12	12	12	12

Special Instructions If Any: NIL

Designed by
Dr. Sunanda Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE4024 : Energy Conservation and Management (Professional Elective IV)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 00 Total Credits : 03	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Nil

Course description:

The course is prepared to provide detailed understanding of energy conservation and management,

Energy, Economics and Environment and their interaction, energy audit and financial management.

Course objectives:

The objectives of the course are

1. Describe the challenges associated with commercial and non-commercial energy
2. Understand the basic knowledge of different terms and principles of energy conservation audit and management and to prepare energy audit report
3. Calculate the simple pay-back period of ENCON opportunities
4. Understand the efficient electricity utilization and identify energy saving potential
5. Understand the efficient heat utilization and identify energy saving potential

Course outcomes:

After completing the course, students will able to

CO1.	Differentiate between commercial and non-commercial energy
CO2	Demonstrate the knowledge of energy conservation and energy audit
CO3	Understand the financial aspects of energy conservation opportunities
CO4	Evaluate the energy saving and conservation in different electrical systems
CO5	Evaluate the energy saving and conservation in different thermal systems

Detailed Syllabus

Unit-I	**Energy Scenario:** Energy sources-primary and secondary, commercial and non-commercial, energy scenario in India and global scenario, Energy security, energy and GDP, energy intensity, energy conservation and its importance, Energy Conservation Act 2001 and related policies, role of non-conventional and renewable energy
Unit-II	**Energy Audit:** Strategy of energy audit, detailed and walkthrough energy audit, comparison with standards, considerations in implementing energy with conservations programs, instruments for energy audit, energy audit of illumination system, energy audit of electrical systems, energy audit of heating ventilation and air conditioning systems, energy audit of compressed air system, energy audit of building, energy audit of thermal systems, distribution and utilization systems, economic analysis, bench marking, energy conservation Act 2003
Unit-III	**Financial Analysis and Management:** Investment need, financial analysis techniques, calculation of simple pay-back period, return on investment, cash flows, risk and sensitivity analysis, time value of money, net present value, breakeven analysis, cost optimization, cost and price of energy services, cost of energy generated through distributed genera

Unit-IV	**Energy efficiency in Electrical Utility:** Losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.
Unit-V	**Energy Efficiency in Thermal Utility:** Compressed air systems: Types of air compressors, compressor efficiency, efficient compressor operation, compressed air systems component, capacity assessment, leakage test, factors affecting the performance and saving opportunities, HVAC and refrigeration systems, vapor compression refrigeration cycle refrigerants, coefficient of performance, capacity factors affecting refrigeration and air conditioning systems, performance and saving opportunities, vapor absorption refrigeration systems, principle types, saving potential, fan and blowers, types, performance evaluation Types of captive power plants, Cogeneration-Cogeneration technologies, industries suitable for cogeneration

Text and Reference Books:

1. Guide books for National Certification Examination for Energy Manager/ Energy Auditors Book-1, General Aspects, Book-2 Thermal Utilities, Book-3 Electrical Utilities, Book-4.
2. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press
3. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
4. Carbon Capture and Sequestration: Integrating Technology, Monitoring and Regulation edited by E J Wilson and D Gerard, Blackwell Publishing
5. Heating and Cooling of Buildings- Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994
6. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)
7. B. E. Kushare "Handbook on Energy Efficient Motors", International Copper promotion counsel (India).

Mapping of Course outcome with program outcomes :

Course outcome	PO 1	PO2	PO 3	PO4	PO 5	PO6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3		1	1	1	1	2	1	1	1	1		1	2	
CO2	3	2	1	1	1	1	2	1	1	1	1	1	1	2	
CO3	3	1	1	1	1	2	1	1	1	1	2	1	1	1	
CO4	3	1	1	1	1	1	1	1	2	1	1	1	1	1	
CO5	3	1	1	1	1	1	1	1	2	1	1	1	1	1	

1- Low 2- Medium 3- High

Sample Assessment Table

Assessment Tool	K1 to K6	K1 to K6	K1 to K6	K1 to K6	K1 to K6
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 25 Marks	5	5	5	5	5
Teachers Assessment 25 Marks	5	5	5	5	5

ISE III Assessment: Teacher's Assessment is based on one of the /or combinations of the few 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**
K1	Remember	5	5
K2	Understand	5	5
K3	Apply	5	5
K4	Analyze	5	5
K5	Evaluate	5	5
K6	Create		
Total		25	25

Designed by
Dr. S. M. Shinde

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4025: Optimal Control System (Program Elective IV)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs/Week	ISE I	: 15 Marks
Tutorial	: 0 Hr/Week	ISE I	: 15 Marks
Total Credits	: 3	ISE III	: 10 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

CO 1	Formulate optimal control problem
CO 2	Minimize the function using calculus of variation
CO 3	Solve dynamic programming problem
CO 4	Minimize function using two boundary value problem
CO 5	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

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

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 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.

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	1	1	1	2		1	1	3		2		2	
CO2	3	3	1	1	1	2		1	1	3		2		2	
CO3	3	3	1	1	1	2		1	1	3		2		2	
CO4	3	3	1	1	1	2		1	1	3		2		2	
CO5	3	3	1	1	1	2		1	1	3		2		2	

1 – Low 2 – Medium 3 – High

1. Teaching Strategies: The teaching strategy is planned 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. 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

3. Assessment table:

Assessment Tool					
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I 15 Marks	8	7			
ISE II 15 Marks			8	7	
ISE III Assessment 10 Marks				05	05
ESE Assessment 60 Marks	12	12	12	12	12

4. Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	ISE 1,2	ISE III Assessment /Assignment	End Semester Examination
K1	Remember	10		20
K2	Understand	10	10	30
K3	Apply		10	10
K4	Analyze			
Total		20	20	60

Designed by Dr. S. S. Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4026: Energized Irrigation Systems (Program Elective IV)	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Hr/Week Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End -Semester Exam : 60 Marks

Course Description: This course is designed to provide an in-depth understanding and analysis of various methodologies used in energized irrigation systems. It emphasizes the study of electrical distribution systems for agricultural power. Students will learn to manually calculate voltage regulation and losses for basic distribution systems, as well as utilize computerized analysis tools for practical applications. Additionally, the course will cover the calculations of water and energy requirements for different types of irrigation systems and crop patterns.

Course Objectives: The objectives of the course are to

1. Understand different methods of energized irrigation systems.
2. Analyze distribution system by manual calculations.
3. Use of computerized analysis tools for distribution systems.
4. Understanding the working of centrifugal pumps and various parameters related to it.
5. Analysis of water and energy requirements as per irrigation method and crop pattern.

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

CO1.	Students shall be able to decide irrigation system requirements using field data.
CO2	Calculate voltage regulation and losses for the distribution system manually.
CO3	Create various scenarios of the distribution system and to use computerized tools for analysis of these distribution system scenarios.
CO4	Understand the working of centrifugal pumps and to perform calculations for pressure and friction head.
CO5	Workout energy and water requirement for an area of interest.

Detailed Syllabus:

Unit-I	**Introduction to Energized Irrigation Systems:** Different types of energized irrigation systems. Field utilization of these irrigation system.
Unit-II	**Electrical Distribution Systems for Agriculture** Draw the SLD of HV and LV distribution system for agriculture power. Calculate voltage regulation and losses of the distribution system. GPS plotting of the distribution system.

Unit-III	**Computerized Tools for analysis of distribution system:** Use of computerized tools for analysis of distribution systems. Creating different scenarios of the distribution system and use of these analyzing tools.
Unit-IV	**Centrifugal pumps:** Different types of centrifugal pumps and its working. Calculating static and friction head and discharge of the pump. Calculating pump efficiency.
Unit-V	**Energy and water requirement:** Irrigation systems used for different crops and water requirements. Calculating energy requirement as per crop pattern.

Text and Reference Books:

Notes provided by IIT-B

Mapping of Course outcome with program outcomes:

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	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 toK6
Course outcomes	CO1	CO2	CO3	CO4	CO5
ISE I 15 Marks	10	5	10	05	
ISE III Assessment 15 Marks			5	5	
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
K2	Understand	5	5		5
K3	Apply		5		10
K4	Analyze				10
Total		10	10		30

Designed by Dr. S. M. Shinde

EEPE4027: Power System Planning, Operation & Control (Program Elective V)	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/Week	ISE I :15 Marks
Tutorial: 0 Hr/Week	ISE I :15 Marks
Credits: 03	ISE III : 10 Marks
	End-Semester Examination : 60 Marks

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

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

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

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

Detailed Syllabus:

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

Text and Reference Books

1. R.N. Sullivan, “Power System Planning” , Tata McGraw Hill
2. A.S. Pabla, “Electrical Power System Planning", Mc Millan India Ltd.
3. L.K. Khirchmayer, “Economic operation of Power System”, Willey Eastern Ltd.
4. P.S.R. Murty, “Power System Operation & control”, Tata McGraw Hill
5. J. Nagrath, D.P.Kothari, “Modern Power System Analysis”, Tata McGraw Hill
6. S. Rao, “EHV-AC, HVDC Transmission & Distribution Engineering”, Khanna Publishers

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

7. Allen J. Wood, and Bruce F. Wollenberg, “Power Generation, Operation and Control”, John
8. Wiley &Sons, Inc., New York.

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

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

Sample Assessment Pattern:

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

Sample Assessment table :

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

Special Instructions if any:

Designed by
Dr. S. P. Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE4028 : Power Quality and Mitigation (Professional Elective V)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 00 Total Credits : 03	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End -Semester Exam : 60 Marks

Course Description: This course gives an introduction on power quality causes and effects, requirement of power quality improvements and mitigation aspects of power quality problem.

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.	Describe Power quality problems and classify power quality events.
CO2	Demonstrate power quality measurement methods
CO3	Explain principle of operation and control of Passive shunt and series compensators.
CO4	Design of Active Shunt And Series Compensators
CO5	Analyze Unified Power Quality Compensators

UNIT-I	**Power Quality an Introduction:** Introduction, Classification of Power quality problems, Causes of power quality problems, Loads that cause power quality problem, classification of nonlinear load, Effects of power quality problems on users, Classification of mitigation techniques for power quality problems
UNIT-II	**Power Quality Standards and Monitoring:** Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, classification of passive power filter, principle of operation of passive power filter
UNIT-III	**Passive Shunt and Series Compensation:** Classification of Passive shunt and series compensators, Principle of operation of Passive shunt and series compensators, Analysis and design of Passive shunt compensators
UNIT-IV	**Active Shunt And Series Compensation:** Classification of DSTATCOMs, principle of operation and control of DSTATCOM, analysis and designed of DSTATCOM, Classification of active series compensators, principle of operation and control of active series compensators, Analysis and design of active series compensators
UNIT-V	**Unified Power Quality Compensators:** Classification of Unified power quality compensators, principle of operation and control of Unified power quality compensators, analysis and designed of Unified power quality compensators

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

Text and Reference Books:

1. Bhim Singh, AmbrishChandra(2015) "Power Quality Problem and Mitigation Techniques" , Wiley Publications (ISBN: 9781118922057)
2. C.Sankaran (2002)" Power quality"CRC Press Publication.
3. Math, H.J. Bollen, "Understanding power quality problem", Standard Publication.
4. Roger C. Dugan, "Electrical power system quality"2nd edition, McGraw-Hill Publication.
5.MohammedA.S.Masoum,EwaldF.Fuchs" Power Quality in power systems and electric machines",2nd Edition, Kindle Edition,(ISBN: 978-0123695369)

Mapping of Course outcome with Program Outcomes

Course outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	1	2	1	1	1	1	1	1	1	1	2	2	
CO2	3	2	1	2	1	1	1		1	1	1	1	2	2	
CO3	3	2	1	1	1	1	1	1	1	1	1	1	2	2	
CO4	3	2	1	2	1	1	1		1	1	1	1	2	2	
CO5	3	2	1	2	1	1	1		1	1	1	1	2	2	

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
Class Test 30 Marks	8	7	8	7	
Teachers Assessment 10 Marks	2	2	2	2	2
ESE Assessment 60 Marks	12	12	12	12	12

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	12
K2	Understand	5	5	2	12
K3	Apply	3	3	3	12
K4	Analyze	2	2	3	12
K5	Evaluate				12
K6	Create				
Total		15	15	10	60

Designed by
Prof. W. A. Gavhane

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4029: Electric Vehicles (Professional Elective V)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 00 Total Credits : 03	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End -Semester Exam : 60 Marks

Prerequisites: 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:

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

Course Outcomes:

After completing the course, students will able to:

CO1	Understand the operation of electrical vehicles.
CO2	Explain Power Converters for Electric and hybrid Vehicles
CO3	Understand the Electrical Machines for Electric and hybrid Vehicles
CO4	Understand the design principles of Electric and hybrid Vehicles
CO5	Understand 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. 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 EV/HEV – Principles, Drive cycles and its detail analysis, sizing of electrical machines
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 WenzhongGao, “Hybrid Electric Vehicles: Principles and Applications with practical prespective”, WIELY, 2011
3. Electric Cars The Future is Now!: Your Guide to the Cars You Can Buy Now and What the Future Holds, by ArvidsLinde, Veloce Publishing,2010.
4. Abu-Rub, Malinowski and Al-Haddad, “Power Electronics for renewable energy systems, transportation, Industrial Applications”, WILEY, 2014.
5. Mehrdad Ehsani, YiminGao, 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
7. Engineers, UK, 2004
8. C.M. Jefferson & R.H. Barnard, “ Hybrid Vehicle Propulsion,” WIT Press, 2002
9. Iqbal Husain, “Electric and Hybrid Vehicles – Design Fundamentals,” CRC Press, 2010
10. James Larminie and John Lowry, “ Electric Vehicle Technology Explained, “ Oxford Brookes University, Oxford, UK, 2003

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	2			2	3	2	2	2		2	2		
CO2	3	1	2			2	3	2	2	2		2		3	2
CO3	3	1	2			2	3	2	2	2		2		3	
CO4	3	2	2			2	3	2	2	2		2			
CO5	3	1	2			2	3	2	2	2		2	2	2	1

1 – Low 2 – Medium 3 – High

ISE III Assessment: Teachers Assessment of 10 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
5. Quiz

Sample Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**Class Test I**	**Class Test II**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	05	05	05	20
K2	Understand	10	10	05	40
K3	Apply				
K4	Analyze	-	-		-
Total Marks: 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2	K1+K2	K1+ K2	K1+K2	K1+K2
	CO1	CO2	CO3	CO4	CO5
Class Test I (15 Marks)	7.5	7.5	-	-	-
Class Test II (15 Marks)	-	-	7.5	7.5	-
Teachers Assessment (10 Marks)	02	02	02	02	02
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by Prof. V. P. Dhote

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EE4030: Restructured Power Systems (Professional Elective IV)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs./Week	ISE I	: 15 Marks
Tutorial	: 00	ISE II	: 15 Marks
Total Credits	: 03	ISE III	: 10 Marks
		End Semester Exam	: 60 Marks

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

Course Objectives:

The objectives of the course are to learn:

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

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

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

Detailed Syllabus:

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

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

Text and Reference Books

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

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

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

Sample Assessment Pattern:

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

Sample Assessment Table:

Assessment Tool	K1+K2	K2+K3	K2+K3	K2+K3	K2+K3
	C01	C02	C03	CO4	CO5
ISE I (15 Marks)	10	05			
ISE II (15 Marks)			10	05	
ISE III Assessment (10 Marks)			5	5	10
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by
Dr. S. P. Ghanegaonkar

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EE4031:Digital Control System (Professional Elective V)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 00 Total Credits : 03	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 Marks End -Semester Exam : 60 Marks

Course description: The purpose of this course is to teach students the fundamental of Digital control systems

Course Objectives:

The objectives of the course are to

1. Explain signal conversion, sampling, reconstruction of signals
2. Illustrate transform analysis of sample data system
3. Explain the design of digital control system
4. Describe the tools of analysis of digital control system
5. Illustrate the modern control techniques

Unit wise Course Outcomes Expected

After completion the course, students will able to:

CO1	To analyze, design and model the signal conversion devices
CO2	To describe the mathematical tools to analyze the discrete time control system
CO3	To design the control system in digital domain using classical design techniques
CO4	To describe the tools of state space analysis for digital control system
CO5	To design control system using state space techniques

Detailed Syllabus:

Unit-I	**Sampling and reconstruction :** Sampled data control system, digital to analog conversion, analog to digital conversion, sample and hold operation, frequency domain consideration in sampling
Unit-II	**Transform analysis of sampled data system :** Linear difference equation,the pulse response, the Z-transform, the pulse transform, block diagram analysis of sample 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 the w and w'-plane, design on the z-plane, digital PID controller, discrete time state equations similarity transformation.
Unit-IV	**State space analysis of sample data systems:** Discrete time state equations, similarity transformations, The cayley-Hamilton theorem, Realization of pulse transfer functions, state equations for sample data systems, concept of controllability and observability.
Unit -V	**Design of Digital controls:** Formulation of the optimal control problem, Optimal state regulators, Eigenvalue assignment by state feedback, state observer

Text and Reference Books:

1. Digital control engineering, M. Gopal, New Age International publication, second edition

2. Control system Engineering, I. J. Nagrath and M. Gopal, New Age International publishers, third edition
3. Discrete-time control systems, Katsuhiko Ogata, Second Edition, PHI publication

Mapping of Course outcome with Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Po13	PO14	PO15
CO1	1	1	1		2										3
CO2	1	3	1		2										3
CO3	1	2	2	2	2										3
CO4	1	3	2	2	2										3
CO5	1	2	2	2	2										3

1- Low 2- Medium 3- High

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

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

Sample Assessment Pattern

Assessment Pattern Level No.	**Knowledge Level**	**Test**	**Teachers Assessment/ Assignment**	**End Semester Examination**
K1	Remember	5		5
K2	Understand	5	5	20
K3	Apply	10		10
K4	Analyze	10	5	15
K5	Evaluate			10
Total Marks 100		30	10	60

Sample Assessment table

Assessment Tool	K1+K2+K3+K4	K1+K2+K3+K4	K1+K2+K3+K4	K3+K4+K5	K3+K4+K5
	C01	C02	C03	CO4	CO5
Class Test (30 Marks)	10	10	10		
Teachers Assessment (10 Marks)	02	02	02	02	02
ESE Assessment (60 Marks)	12	12	12	12	12

Designed by Dr. Sandhya Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024

EEPE 4032 Applications of Embedded Systems	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** ISE I : 15 Marks ISE II : 15 Marks ISE III : 10 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.
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"

Mapping Of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 13	PSO 14	PSO 15
CO1	3	2				1			1	1		1		2	
CO2	3	2				1			1	1		1		2	
CO3	3	2				1			1	1		1		2	
CO4	3	2				1			1	1		1		2	
CO5	3	2				1			1	1		1		2	

1-Low, 2-Medium 3- High

ISE III Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

5. Presentation on latest topics/Real life problems related with the subject
6. Problems based on GATE questions
7. Simulations problems
8. Quiz

Sample Assessment Pattern:

Sample Assessment Pattern Level No.	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	5	5		10
K2	Understand	5	5	5	30
K3	Apply	5	5	5	

K4	Analyze				
K5	Evaluate				
K6	Create				
Total Marks 100		15	15	10	60

Sample Assessment Table:

Assessment Tool	K1+K2+	K2+ K3	K2+ K3	K2	K2+ K3
	CO1	CO2	CO3	CO4	CO5
ISE I (15 Marks)	7.5	7.5			
ISE II (15 Marks)			7.5	7.5	
ISE III (10 Marks)				5	5
ESE Assessment (60 Marks)	10	20	10	10	10

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:

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. Sandhya Kulkarni

Approved in XXV IIIth Academic Council
Dated: 25th Jun 2024