PROGRESSIVE EDUCATION SOCIETY'S

MODERN COLLEGE OF ENGINEERING

1186A, SHIVAJINAGAR, OFF J.M, PUNE-411005

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE

DEPARTMENT OF ELECTRICAL ENGINEERING

E-CURRICULUM BOOKLET

(2019 Course)

FOR THE PROGRAMME

BE – ELECTRICAL ENGINEERING

(SEMISTER-I)

QUALITY POLICY OF THE INSTITUTE

We, PES Modern College of Engineering are committed to develop and foster cultured and promising professionals by imparting quality education in the field of Engineering and Management.

VISION OF THE INSTITUTION

To create a collaborative academic environment to foster professional excellence and ethical values

MISSION OF THE INSTITUTE

1. **To develop ethical standards capable of creating and managing global enterprises.**
2. **To foster innovation and research by providing a stimulating learning environment.**
3. **To ensure equitable development of students of all ability levels and backgrounds.**
4. **To be responsive to changes in technology, socio-economic levels and environmental conditions.**
5. **To foster and maintain mutually beneficial partnerships with alumni and industry.**

QUALITY POLICY OF THE DEPARTMENT

Electrical Engineering department is committed to develop promising engineers with ethical and social responsibility through excellence in academics, research, skill development and consultancy.

VISION OF THE DEPARTMENT

To build technically competent Electrical Engineers with ethical and social responsibility.

MISSION OF THE DEPARTMENT

- **To develop abilities in students for acquiring knowledge and skills to flourish in dynamic technical environment.**
- **To nurture cultured professionals by providing facilities for their overall development.**
- **To motivate the students for research work and activities beneficial to society.**
- **To enhance strong bonding with various organization and alumni.**

Program Educational Objectives (PEOs)

Graduates will be able to:

PEO 1: Solve and analyze problems in Electrical Engineering using fundamental knowledge.

PEO 2: Adopt lifelong learning ability by acquiring various skills.

PEO 3: Practice ethically in their profession.

PEO 4: Achieve global competency through interactions with various industries, research and professional organizations.

PROGRAM OUTCOMES (POs)

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

PO2. Problem analysis: Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: The problems that cannot be solved by straight forward application of knowledge, theories and technique applicable to the engineering discipline that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (Like: cost, power requirement, durability, product life, etc.). Which need to be defined (modeled) within appropriate mathematical framework that often requires use of modern computational concepts and tools.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: 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 documentation, make effective presentations, and give and receive clear instructions.

PO11. 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 and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES:

PSO1: Students will be able to apply logical and technical concepts of automation, control syste and electric mobility.

PSO2: Students will be able to develop adequate competency in electrical energy manageme through conventional and non-conventional energy sources.

CORE VALUES

- Excellence in the field of Electrical Engineering.
- Social responsibility with integrity.
- Lifelong Learning.
- Unity in Diversity.

SHORT TERM GOALS

- To enhance alumni interaction.
- To develop innovation lab to enhance research and entrepreneurship by providing various facilities.

LONG TERM GOALS

- To promote consultancy activity for revenue generation by developing high-tech standard laboratory.
- To encourage the faculty for research work and up gradation of qualifications.
- To enhance teaching-learning process through ICT.
- To establish competitive entrance exam cell in department.

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Course Structure

BE Electrical (2019 Course)

SEM-I

Course Code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	PW	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	PW	Total
403141	Power System Operation & Control	3	2	–	–	30	70	25	–	25	150	3	1	–	–	4
403142	Advanced Control System	3	2	–	–	30	70	–	–	50	150	3	1	–	–	4
403143	Elective-I	3	2	–	–	30	70	–	–	25	125	3	1	–	–	4
403144	Elective-II	3	–	2*	–	30	70	25	–	–	125	3	–	1	–	4
403145	Project Stage-I	–	–	–	4	–	–	50	–	50	100	–	–	–	2	2
403146	MOOCs	–	–	–	–	–	–	50	–	–	50	–	–	–	2	2
403147	Audit Course-VII	2#	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total		12	6	2	4	120	280	150	–	150	700	12	3	1	4	20

403143: Elective-I	403144: Elective-II	403147: Audit Course-VII
403143A: PLC and SCADA 403143B: Power Quality Management 403143C: High Voltage Engineering 403143D: Robotics and Automation	403144A : Alternate Energy System 403144B : Electrical & Hybrid Vehicle 403144C : Special-purpose Machines 403144D: HVDC & FACTS	403147 A: German Language I 403147B: Engineering Economics I 403147C: Sustainability(IGBC)

SEM-II

Course Code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	PW	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	PW	Total
403148	Switchgear and Protection	3	2	–	–	30	70	25	–	50	175	3	1	–	–	4
403149	Advanced Electrical Drives & Control	3	2	–	–	30	70	25	50	–	175	3	1	–	–	4
403150	Elective-III	3	–	–	–	30	70	–	–	–	100	3	–	–	–	3
403151	Elective-IV	3	–	–	–	30	70	–	–	–	100	3	–	–	–	3
403152	Project stage II	–	–	–	12	–	–	100	–	50	150	–	–	–	6	6
403153	Audit course VIII	2#	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total		12	4	–	12	120	280	150	50	100	700	12	2	–	6	20

403150: Elective-III	403151: Elective-IV	403153: Audit Course-VIII
403150 A : Digital Control System 403150 B : Restructuring and Deregulation 403 150 C: Smart Grid 403150 D: SensorTechnology (Open Elective)	403151A: EHV AC Transmission 403151B : Illumination Engineering 403151C: Electromagnetic Fields 403151D: AI and ML (Open Elective)	403153A: German Language II 403153B: Engineering Economics II 403153C: Green Building

*** For the tutorial, one credit is given. # Audit Course: Conduct over and above these lectures.**

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DEPARTMENT OF ELECTRICAL ENGINEERING

Power System Operation and Control

(403141)

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Name of the Subject – Power system operation & control

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	25	150	4 (3+1)

Syllabus:

Unit 01: Power System Stability (Angle Control): (8 hrs)

Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and reclosure), methods to improve steady state and transient stability, numerical based on equal area criteria.

Unit 02: Reactive Power management: (8 hrs)

The necessity of reactive power control, production and absorption of reactive power, reactive power requirements for power factor control and voltage regulation and the loading capability curve of a synchronous generator, types of FACTS controller.

Series compensation: reactor and capacitor, TCSC, SSSC.

Shunt compensation: reactor and capacitor, STATCOM, FC-TCR. Series and shunt compensation: UPFC. (FACTS devices: working principle, circuit diagram, VI characteristics, applications)

Unit 03: Automatic Generation Control (Frequency Control): (08 hrs)

Introduction to the concept of AGC; complete block diagram representation of load, frequency

control of an isolated power system; steady state and dynamic response; control area concept; two-area load-frequency control; Schematic and block diagram of the alternator voltage regulator scheme

Unit 04: Economic Load Dispatch and Unit Commitment (Cost Control): (8 hrs)

- **Part A: Economic load dispatch**: Introduction, revision of cost curve, incremental cost curve of thermal, method of Lagrange multiplier, exact coordinate equation (penalty factor), economic scheduling of thermal plant considering effect of transmission losses using Bmn coefficient. (Numerical on method of Lagrange multiplier, penalty factor, Bmn coefficient)
- **Part B: Unit commitment**: Concept of unit commitment, constraints in unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming, Numerical on priority list and dynamic programming method

Unit 05: Energy Control:

Interchange of power between interconnected utilities (numerical), economic interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.

Unit 06: Voltage Stability:

Basic concepts related to voltage stability: transmission system characteristics (PV curve), generator characteristics (QV curve), and load characteristics. Voltage collapse, classification of voltage stability, static and dynamic stability, analysis techniques for dynamic voltage stability, voltage stability indexing.

Text Books:

[T1] I. J. Nagrath, D. P. Kothari, “Modern Power System Analysis”, 4thEdition, Tata McGraw Hill Publishing Co. Ltd. (Edition 2)

[T2] T. J. E. Miller, "Reactive power control in electric systems," Willey.

[T3] Hadi Saadat, "Power System Analysis," Tata McGraw's Hill

[T4]S. Sivanagaraju, G. Sreenivasan, "Power System Operation and Control," Pearson Education India, 2009.

[T5] P. S. R. Murthy, "Power System Operation & Control", Tata McGraw Hill Publishing Co. Ltd.

[T6] Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control," Prentice Hall of India.

[T7] Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTs," IEEE Press.

[T8] Dr. B.R. Gupta, "Power System-Analysis and Design", S. Chand Publication.

References:

[R1]. Allen J. Wood, Bruce F. Wollenberg "Power Generation, Operation, and Control", Wiley India Edition.

[R2]. R. Mohan Mathur, Rajiv K. Varma, "Thyristor based FACTS controller for electrical transmission systems", by John Wiley and Sons, Inc

[R3]. Olle I. Elgerd, "Electrical Energy System Theory", 2nd Edition, Tata McGraw-Hill Publishing Co. Ltd.

[R4] Dr. K. Uma Rao, "Power System Operation and Control," Wiley India

[R5] Prabha Kundur, "Power System Stability and Control," Tata McGraw's Hill

[R6] "Electrical Power System Handbook", IEEE Press

[R7] James Momoh, "Smart Grid: Fundamentals of design and analysis," Wiley, IEEE Press

Online Resources:

[O1] https://www.youtube.com/playlist?list=PL86E9AC8CFBA00ADB

[O2] https://onlinecourses.nptel.ac.in/noc19_ee62/preview

[O3]https://www.youtube.com/watch?v=uy9lZCdkQIM&list=PLD4ED2FAF3C1525

[O4] http://nptel.ac.in/courses/108101040/ (PSOC webcourse)

[O5] https://nptel.ac.in/courses/108101004

[O6] https://onlinecourses.nptel.ac.in/noc21_ee16/preview

Course Objectives

This course aims to:

1. Study the different types of angle, voltage and frequency stability of the power system and methods to improve the stability of the power system.
2. Impart knowledge about various advanced controllers such as FACTs controllers with its evolution, principle of operation, circuit diagram and applications.
3. Introduce frequency control in a single area and two area system.
4. Understand the formulation of unit commitment and economic load dispatch.
5. Illustrate various ways of interchange of power between interconnected utilities.

Course Outcomes:

After successfully completing the course students will be able to:

CO1: Summarize angle, voltage and frequency stability in the power system control (UN).

CO2: Illustrate various ways of interchange of power between interconnected utilities (AP).

CO3: Analyze stability and optimal load dispatch using different techniques (AN).

CO4: Select appropriate FACTS devices for stable operation of the system (EV).

CO5: Evaluate the stability of the system and suggest the methods to improve it (EV).

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Academic Activity Planner

Units	Unit Test1 (10marks)	Unit Test2 (10marks)	Assignment No:1 (10marks)	Assignment No:2 (10marks)	OBT : (10marks)	MCQ (10marks)
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

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Teaching Plan

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Power System Stability	12
2	II A	Reactive Power management	3
3	II B	FACTs Technology	4
4	III	Automatic Generation and Control (AGC)	8
5	IV A	Economic Load Dispatch	4
6	IV B	Unit Commitment	4
7	V	Energy Control	6
8	VI	Voltage Stability	7

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Unit wise Lecture Plan

Unit No. I: Power System Stability

Pre-requisites:

- Concepts of Power system-I & II

Objectives:

- Study the different types of angle, voltage and frequency stability of the power system and methods to improve the stability of the power system.

Course Outcomes

After successfully completing the course students will be able to:

- CO1: Summarize angle, voltage and frequency stability in the power system control (UN).
- CO3: Analyze stability and optimal load dispatch using different techniques (AN).
- CO5: Evaluate the stability of the system and suggest the methods to improve it (EV).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to stability, dynamics of synchronous machine	T2, T1	Chalk & Talk
2	Swing equation, power angle equation and curve	T2, T1	Chalk & Talk
3	Types of power system stability (concepts of steady state, transient, dynamic stability)	T2, T1	Chalk & Talk
4	Equal area criterion	T2, T1	PPT
5	Applications of equal area criterion (sudden change in mechanical input)	T2, T1	PPT
6	Effect of clearing time on stability, critical clearing angle, short circuit at one end of line	T2, T1	Chalk & Talk
7	Applications of equal area criterion (short circuit at middle of the line,)	T2, T1	Chalk & Talk

8	Steady state stability limit	T2, T1	Chalk & Talk
9	Methods to improve steady state and transient stability	T2, T1	Chalk & Talk
10	Numerical based on equal area criteria	T2, T1,R5	Chalk & Talk
11	Numerical based on equal area criteria	T2, T1,R5	Chalk & Talk
12	Flip lecture		Demonstration of Synchronous machine

Question Bank – Unit I

1. Define stability and explain dynamics of synchronous machine.
2. Derive swing equation expression.
3. Explain power angle equation and obtain power angle curve.
4. Explain types of power system stability (concepts of steady state, transient, dynamic stability)
5. Explain Equal area criterion.
6. Effect of sudden change in mechanical input for equal area criterion.
7. Explain effect of clearing time on stability, critical clearing angle.
8. Explain effect of short circuit at one end of line in a SMIB system.
9. Explain effect of short circuit at middle of the line in a SMIB system.
10. State the methods to improve steady state and transient stability.

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Unit No. II: Reactive Power Control

Pre-requisites:-

- Basic concepts of Apparent, active and reactive power.

Objectives:-

- Impart knowledge about various advanced controllers such as FACTs controllers with its evolution, principle of operation, circuit diagram and applications.

Course Outcomes

After successfully completing the course students will be able to:

- CO4: Select appropriate FACTS devices for stable operation of the system (EV).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	The necessity of reactive power control, production and absorption of reactive power,	R4,R5, T2	Chalk & Talk
2	reactive power requirements for power factor control and voltage regulation	R4,R5, T2	PPT
3	Loading capability curve of a generator	R4,R5, T2	PPT
4	Problems of AC transmission system, Evolution of FACTs technology	R4,R5, T2	PPT
5	Principle of operation, Circuit diagram & explanation, Applications of SVC, TCSC	R4,R5, T2	Chalk & Talk
6	Series compensation: reactor and capacitor, TCSC, SSSC: working principle, circuit diagram, VI characteristics, applications	R4,R5, T2	PPT
7	Shunt compensation: reactor and capacitor, STATCOM, FC-TCR working principle, circuit diagram, VI	R4,R5, T2	PPT

	characteristics, applications		
8	Series and shunt compensation: UPFC.	R4,R5, T2	PPT

Question Bank: Theory

Unit 2:

1. Explain the Necessity of reactive power in the power system.
2. Explain necessity of reactive power control and also explain the effect of excitation on reactive power
3. What is loading capability curve of a generator? Explain.
4. How compensation in power system is carried out (series and shunt) & also mention problems associated with it.
5. Describe the problems of Problems of AC transmission system
6. Write a note on evolution of FACTs technology.
7. Explain the FACTs methodology with a neat circuit diagram.
8. Describe working principle, VI characteristics and the applications of SVC, TCSC.
9. Describe working principle, VI characteristics and the applications STATCOM, SSSC and UPFC.

Unit No.-III: Automatic Generation Control (Frequency Control)

Pre-requisites:-

- Basic concepts of power system operation and basics of control system.

Objectives:-

- Introduce frequency control in a single area and two area system.

Course Outcomes

After successfully completing the course students will be able to:

- CO1: Summarize angle, voltage and frequency stability in the power system control (UN).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to the concept of AGC;	T1,T5,R1 IS: 4029 – Testing of 3 Phase Induction Motor.	PPT
2	Complete block diagram representation of load frequency control of an isolated power system	R5,R4, T2	Chalk & Talk
3	Complete block diagram representation of load frequency control of an isolated power system	R5,R4, T2	Chalk & Talk
4	Steady state response	R5,R4, T2	Chalk & Talk
5	Dynamic response	R5,R4, T2	Chalk & Talk
6	Control area concept	R5,R4, T2	Chalk & Talk
7	Two area load frequency control.	R5,R4, T2	Chalk & Talk
8	Concept of AGC	R5,R4, T2	PPT

Question Bank: Theory

Theory Paper

Unit No.-III

1. Describe the concept of AGC.
2. Explain with complete block diagram representation of load frequency control of an isolated power system.
3. Write a note on Steady state and dynamic response.
4. What is control area concept? Explain two area load frequency control.
5. With a schematic diagram explain alternator voltage regulator scheme.

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Unit No.-IV: Economic load dispatch unit commitment

Pre-requisites:-

- Basics of load dispatch and market scenario

Objectives:-

- Understand the formulation of unit commitment and economic load dispatch.

Course Outcomes

After successfully completing the course students will be able to:

- CO3: Analyze stability and optimal load dispatch using different techniques (AN).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction, revision of cost	T2, T3, R4	Chalk & Talk
2	Revision of cost curve of thermal and hydropower plant	T2, T3, R4	Chalk & Talk
3	Plant scheduling method, equal incremental cost method,	T2, T3, R4	Chalk & Talk
4	Method of Lagrange multiplier neglecting transmission losses	T2, T3, R4, R5	Chalk & Talk
5	B_{mn} coefficient, economic scheduling of thermal plant considering effect of transmission losses	T2, T3, R4, R5	PPT
6	Penalty factor, numerical	T2, R5	Chalk & Talk
7	Concept of unit commitment, constraints on unit commitment spinning reserve	T2, R5	PPT
8	Thermal and hydro constraints, methods of unit commitment priority list and dynamic programming	T2, R5	PPT

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Question Bank

Theory - Unit No. - IV

1. Explain the concept of economic load dispatch.

2. Write short notes on plant scheduling method, equal incremental cost method.

3. Explain the method of Lagrange multiplier neglecting transmission losses.

4. Define B_{mn} coefficient.

5. Explain the method of economic scheduling of thermal plant considering effect of transmission losses.

6. Describe penalty factor.

7. Describe the concept of unit commitment and hence explain constraints on unit commitment spinning reserve

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Unit No.-V: Energy Control:

Pre-requisites:

- Basic concepts of energy and power distribution.

Objectives: -

- Illustrate various ways of interchange of power between interconnected utilities

Course Outcomes

After successfully completing the course students will be able to:

- CO2: Illustrate various ways of interchange of power between interconnected utilities (AP).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Interchange of power between interconnected utilities,	T2, T3, R4	PPT
2	Economy interchange evaluation, , types of interchange	T2, T3, R4	PPT
3	interchange evaluation with unit commitment	T2, T3, R4	PPT
4	Capacity and diversity interchange, energy banking,	T4, T3, R4	PPT
5	Emergency power interchange, inadvertent power exchange, power pools	T4, T3, R5	PPT

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Question Bank: Theory

Theory Paper

1. Explain how interchange of power takes place between interconnected utilities.
2. Describe economy interchange evaluation. Also explain interchange evaluation with unit commitment &types of interchanges.
3. Define reliability of power system hence give hierarchical levels for reliability study.
4. Explain how reliability evaluation of generation system is carried out.
5. Define loss of load probability (LOLP), loss of load expectation (LOLE).
6. What is EENS, explain with respect to generation model and load model.
7. How is distribution system reliability evaluation for radial and parallel system carried out?
8. Describe customer oriented and energy based reliability indices.

Unit 06: Voltage Stability:

Course Objectives

- Study the different types of angle, voltage and frequency stability of the power system and methods to improve the stability of the power system.

Course Outcomes:

After successfully completing the course students will be able to:

- CO1: Summarize angle, voltage and frequency stability in the power system control (UN).
- CO5: Evaluate the stability of the system and suggest the methods to improve it (EV).

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Basic concepts related to voltage stability:,	T1 T2 R4,R5,	PPT and chalk
2	Transmission system characteristics (PV curve), generator characteristics (QV curve), and load characteristics.	T1 T2 R4,R5,	PPT and chalk
3	Transmission system characteristics (PV curve), generator characteristics (QV curve), and load characteristics.	T1 T2 R4,R5,	PPT and chalk
4	Voltage collapse, classification of voltage stability, static and dynamic stability	T1 T2 R4,R5,	PPT and chalk
5	Analysis techniques for dynamic voltage stability	T1 T2 R4,R5,	PPT and chalk
6	Voltage stability indexing.	T1 T2 R4,R5,	PPT

Question Bank: Theory

Theory Paper

1. Explain voltage stability in power system.
2. Explain the significance of Transmission system characteristics (PV curve).
3. Explain the significance of generator characteristics (QV curve) with respect to load characteristics.
4. What is Voltage collapse? Discuss the conditions leading to voltage collapse.
5. Classify and explain different types of voltage stability.
6. Explain Analysis techniques for dynamic voltage stability.
7. Write a short note on: Voltage stability indexing

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Practical Assessment

List of Experiments

Sr.No.	Name of the Practical
1	To determine Steady state stability of medium transmission line (performance).
2	To plot swing curve by Point by Point method for transient stability analysis.
3	To apply equal area criteria for analysis stability under sudden rise in mechanical power input
4	To apply equal area criteria for stability analysis under fault condition.
5	To study reactive power compensation using any FACTS device.
6	To study Lagrange multiplier technique for economic load dispatch
7	To study load frequency control using approximate and exact model.
8	To study load frequency control with integral control.
9	To study the two area load frequency control.

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Advanced Control System

(403142)

PROGRESSIVE EDUCATION SOCIETY'S

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Name of the Subject –Advanced Control System

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	3	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	50	-	150	

Syllabus:

Unit 01 Compensator Design in Frequency Domain (06 hrs)

Approach to control system design, cascade compensation networks, phase-lead and phase-lag compensator designs using bode plot, physical realization of compensators.

Unit 02 Nonlinear Control Systems (07 hrs)

introduction to nonlinear systems, common nonlinearities, describing function method, describing function of an ideal relay, stability analysis with describing function, introduction to Lyapunov stability analysis (basic concepts, definitions, and stability theorem)

Unit 03 Introduction to State-Space (08 hrs)

Concept of state, state-space representation of dynamical systems in physical variable form, phase variable forms and Jordon / diagonal canonical form, conversion of the transfer function to state-space model and vice versa, state equation and its solution, state transition matrix and its properties, computation of state transition matrix by Laplace transform and Caley Hamilton method.

Unit 04 State-Space Design (08 hrs)

The concept of controllability and observability, Kalman's and Gilbert's tests for controllability and observability, effect of pole-zero cancellation, duality property, control system design using pole

placement using transformation matrix, direct substitution, and Ackermann's formula, State observers, design of a full order observer.

Unit 05 Introduction to Digital Control System (08 hrs)

Basic block diagram of the digital control system, sampling and reconstruction, Shannon's Sampling theorem, zero-order hold and its transfer function, First-order hold (no derivation), characteristics equation, mapping between s-plane and z-plane, stability analysis in z-plane.

Unit 06 Advanced control system topics (08 hrs)

Concept of sliding mode control, equivalent control, chattering, sliding mode control based on reaching law, Introduction to adaptive control, adaptive schemes, and control problems Optimal control-linear quadratic regulator problem.

Text Books:

[T1] Norman S. Nise, Control System Engineering, Sixth Edition, John Wily and Sons, Inc. 2011.

[T2] Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Twelfth Edition, Pearson Education.

[T3] Benjamin C. Kuo, Digital Control System, Second Edition, Oxford University Press, 2003.

[T4] I. J. Nagarath, M. Gopal, Control System Engineering, Fourth Edition, New Age International (P) Limited, Publishers

[T5] A. Nagoor Kani, Advanced Control Theory, Third Edition, CBS Publishers and Distributes, 2020.

Reference Books:

[R1] Katsuhiko Ogata, Modern Control Engineering, Fifth Edition, Prentice-Hall, 2010.

[R2] M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill.

[R3] K. Ogata, Discrete-Time Control System, Second Edition, PHI Pvt. Ltd. 2006

[R4] M. Gopal, Modern Control Systems Theory, Second Edition, New Age International (P) Limited, Publishers

[R5] Karl J. Åström, Björn Wittenmark, Adaptive Control, Second Edition, Dover Publications, Inc. New Yark

[R6] C Edwards, Sarah K. Spurgeon, S Spurgeon, Sliding Mode Control: Theory And Applications, Taylor and Francis, 1998

[R7] Jean-Jacques E. Slotine, Jean-Jacques E.. Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall, 1991.

Online Resources:

BE Electrical (2019 Course)

[O1] https://nptel.ac.in/courses/108102043

[O2] https://nptel.ac.in/courses/108102113

Course Objectives:

1.. Introduce concepts of modern control theory, analysis, and design.

2. Provide an overview of the digital control system and nonlinear control system.

3. Explore advanced control techniques at an introductory level.

Course Outcomes:

After successfully completing the course students will be able to:

1. Students will be able to design lead and lag Compensator in Frequency domain.
2. Students will be able understand common Nonlinearities.
3. Students will be able to understand and formulate state space technique.
4. Students will be able to evaluate solution of state equation by various methods

5. Students will be able to analyze the stability of Digital Control System.

6. Students will be able to understand the concepts of advanced controls.

Academic Activity Planner

Units	Unit Test1 (10marks)	Unit Test2 (10marks)	Assignment No:1 (10marks)	Assignment No:2 (10marks)	OBT : (10marks)	MCQ (10marks)
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

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DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching Plan

Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	References/ Text book	Total Lecture Planned
1	I	Compensator Design in Frequency Domain	T1,T2 R1,R2	06
2	II	Nonlinear Control Systems	T1,T2 R2,R3	07
3	III	Introduction to State-Space	T1,T2 R2	08
4	IV	State-Space Design	T3, T4 R1, R3	08
5	V	Introduction to Digital Control System	T3, T4 R1, R3	08
6	VI	Advanced control system topics	T3, T4 R1, R3	08

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Unit wise Lecture Plan

Unit No.-I: Compensation Techniques.

Prerequisites:-

- Basic concepts Matrix Algebra

Objectives :-

- To understand the concept of compensation.
- To understand the physical realization of the compensator.

Outcomes :

- Students will be able to design lead and lag Compensators in the Frequency domain.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Design of Linear Control System, Common compensating network	**T1,R2**	Chalk and Talk
2	Transfer function of Lag, Lead and Simple lag-lead network	**T1,T2**	Chalk and Talk
3	Physical realization of compensators using active and passive elements	**T3,R1**	Chalk and Talk
4	Tachometer feedback compensation	**T1,T3**	Chalk and Talk
5	Problems on Lag, Lead and Simple lag-lead network	**T2,T3**	Chalk and Talk
6	Problems on Lag, Lead and Simple lag-lead network	**T1,T2,R1**	Chalk and Talk

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Question Bank: Theory

Unit No.-I

Q. 1 What is the need of compensation? What are the different types of compensating network? [4]

Q2 Design the suitable lead compensator for 10/{s(s+10}. [6]

(a)Kv=20/sec,

(b)Phase margin>=50 0

(c)Gain Margin >=10 db

Q. 3 The forward path transfer function of a certain unity feedback control system is given by $G(S)= K/\{S(S+2)(S+30)\}$ [6]

The system has to satisfy following specifications

(a)Phase margin>=350

(b)Gain Margin >=20 db

(c)Steady state error coefficient for unit ramp input <=25

Design the suitable lead compensator.

Q. 4 What is lead compensator? Derive it's transfer function. [5]

Q. 5 Compare Lead and lag compensator [5]

Q. 6 Derive Transfer Function for Lead network. Show its pole zero configuration. [5]

Unit No.-II: Nonlinear Control System Analysis

Pre-requisites:-

- Graphic Isocline Method.

Objectives:-

- To familiarize with various non-linearities and their behavior observed in the physical system.
- To understand describing the function method and phase plane method.

Outcomes:- After successfully completing this unit students will be able to:

- Analyze understands various non-linearities in the physical system.

Lecture No.	Details of the Topic to be covered	References
1	Classification, Common types of non-linearity's observed in physical system	**T1,T3,R1**
2	Sub harmonics response, jump resonance, limit cycle	**T1,T2,R1**
3	Amplitude as function of frequency oscillation	**T1,T3,R1**
4	Non-linear spring mass system	**T1,T3,R1**
5	Sub-harmonic oscillation	**T1,T2,R1**
6	Analysis of NLC using phase plane method for Ideal Relay	**T1,T3,R1**
7	Analysis of NLC using Describing function method for Ideal Relay	

Question Bank

Unit No.-II

Q1 Explain for nonlinear system.

(i)Jump resonance

(ii)Limit cycle

(iii)Asynchronous quenching

(iv)Subharmonic oscillations

Q2 Explain stability analysis with describing function.

Q3 Derive describing function of Ideal relay

Q4 Explain various nonlinearities present in the systems.

Q.5 Explain phenomenon exhibited by nonlinear system subharmonic Oscillation, asynchronous quenching, frequency entrainment

Q6 State and explain different types of singular points, also draw phase portrait for the same.

Q7 Explain briefly

i) Positive definite

ii) Negative definite.

iii) Positive Semidefinate.

iv) Negative Semidefinate.

Unit No.-III: Introduction to State Space

Pre-requisites:-

- Basic concepts of Matrix Algebra.

Objectives:-

- To understand the concept of state and to be able to represent a system in state space format
- To understand and able to solve state equation and familiarize with STM and its properties.

Outcomes:- After successfully completing this unit students will be able:

- Understand and formulate state space technique.

Lecture No.	Details of the Topic to be covered	References
1	Important definitions- state, State variable, state vector, state space, state equation, Output equation.	**T1,T2**
2	State space representation of electrical network	**T1.T3,R2**
3	Conversion of transfer function to state space and vice-versa	**T2,T3**
4	phase variable forms and Jordon / diagonal canonical form	**T2,T3**
5	Evaluation of STM.	**T1**
6	Properties of STM	**T1,T2**
7	Computation of state transition matrix by Laplace transform and Caley Hamilton method	**T1.T3,R2**

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Question Bank: Theory

Unit 3

Q. 1 Explain advantages of state variable method over conventional one. [4]

Q2 Define terms state, State variable, state vector, state space, state equation, Output equation. [6]

Q. 3 Find the state transition matrix using Laplace inverse method and Caley Hamilton method. [6]

$$A=\begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$$

Q. 4 State properties of state transition matrix [5]

Q. 5 [5]

$$\dot{x} = [0\ 1\ 0\ 0\ 0\ 1\ -6\ -11\ -6\ ]x + [0\ 1\ 1\ ]u$$

Y=[4 5 1]

Find the transfer function for the above system.

Q. 6 Diagonalize the following [5]

$$A=\begin{bmatrix} -4 & 1 & 0 \\ 0 & -3 & 1 \\ 0 & 0 & -2 \end{bmatrix}$$

Q. 7 [5]

Convert the T.F. into phase variable state space form

$$G(s) = \frac{s-3}{s^3 - 9s^2 - 24s - 20}$$

Q.8 Explain construction of state model by direct decomposition and parallel decomposition with diagram. [5]

Q9 $[\dot{x_1}\ \dot{x_2}\ ] = [0\ -2\ 1\ -3\ ][x_1\ x_2\ ]$ + [0 1] u [5]

Y= [1 0] $[x_1\ x_2\ ]$

X(0) = [0 1]

Obtain x(t) for the unit step input at t=0.

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Unit IV: State Space Design

Pre-requisites:-

- Sate Space basics, Matrix basics.

Objectives:

- After successfully completing this unit students will be able to:
- Design a control system using state space techniques including state feedback control and full order observer.

Outcomes:

- Students will be able to evaluate solution of state equation by various methods

Lecture No.	Details of the Topic to be covered	References
1	Concept of controllability and observability. Controllability and observability tests.	T3,T4,R1,R3
2	Condition of controllability and observability from the system matrices in canonical form,Jordon canonical form	T3,T4,R1,R3
3	Effect of pole Zero cancellation on controllability and observability of the system	T3,T4,R1,R3
4	Duality property	T3,T4,R1,R3
5	Pole placement design by state variable feedback.	T3,T4,R1,R3
6	Necessity of an observer	T3,T4,R1,R3
7	Design of Full order Observer	T3,T4,R1,R3

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Question Bank: Theory

Unit No.-VI

Q1 Define controllability and observability. Explain any one method to determine it.

Q2 For the following system determine controllability and observability.

$$A=\begin{bmatrix}-1 & 1 & 0\\ 0 & -4 & 2\\ 0 & 0 & -10\end{bmatrix},\quad B=\begin{bmatrix}1\\0\\1\end{bmatrix},\quad c=[1\ 0\ 1]$$

Q3 For the following system determine controllability and observability.

$$A=\begin{bmatrix}0 & 0 & 0\\ 1 & 0 & -3\\ 0 & 1 & -4\end{bmatrix};\quad C=[0\quad 0\quad 1]\qquad B=\begin{bmatrix}1\\0\\1\end{bmatrix}$$

Q4 Explain the procedure to design state observer.

Q5 A system is given by x=Ax+By

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix},\quad B=\begin{bmatrix}0\\0\\1\end{bmatrix}$$

It is desired to place close loop poles at -2,-1 +- j

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Unit No.-V: Introduction to Digital Control System

Pre-requisites:-

- Analog to Digital Conversion and vice versa, Review of z-transform

Objectives:-

- To understand the basic digital control scheme, concept of sampling and reconstruction.

Outcomes:

- Students will be able to analyze the stability of Digital Control System.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to digital control system, History of development of control system. Configuration of the basic digital control system.	T1	Video and PPT
2	Configuration of the basic digital control system. Advantages and limitations of digital control	T1,T2	PPT
3	System data conversion and quantization, Sampling and,	T3,R1	Chalk and Talk
4	Reconstruction processes, Shannon's Sampling theorem	T1,T3	Chalk and Talk
5	Practical aspects of choice of sampling rate, Zero order hold (ZOH) and it's transfer function	T2,T3	Chalk and Talk
6	Basic concepts of first order hold	T1,T2,R1	Chalk and Talk
7	characteristics equation Mapping between s-plane and z-plane	T1,T2,R1	Chalk and Talk

8	stability analysis in z-plane	T1,T2,R1	Chalk and Talk

Question Bank: Theory

Unit :V

Q1. Explain basic configuration of basic digital control scheme.

Q2. Explain data conversion and Quantization in digital control scheme.

Q3.Explain ZOH and its transfer function.

Q4.Explain sampling theorem and Reconstruction process.

Q5.Explain practical aspects of choice of sampling rate.

Q6.Draw the block diagram of digital control system and explain the function of each block

Q7. Explain mapping s-plane with z-plane.

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Unit No.-VI: Advanced control system topics

Pre-requisites:-

- Basic concepts control system

Objectives:-

- Explore advanced control techniques at an introductory level

Outcomes: - After successfully completing this unit students will be able:

Students will be able to understand the concepts of advanced controls.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Concept of sliding mode control	T1,T2	Chalk and Talk
2	Equivalent control, chattering, sliding mode control based on reaching law.	T1.T3,R2	Chalk and Talk
3	Introduction to adaptive control	T2,T3	Chalk and Talk
4	Various adaptive schemes	T2,T3	Chalk and Talk
5	control problems	T1	Chalk and Talk
6	Optimal control-linear quadratic regulator problem.	T1,T2	Chalk and Talk

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Question Bank: Theory

Unit No.-VI

Q1 Explain the terms

i)Sliding Phase

ii) Reaching Phase

Q2 Write a short note on Input – Output Linearization

Q3 Write a short note on Chattering as used in Sliding Control.

Q4 Explain the following

i)Concept of Variable Structure Control

ii)Properties of Sliding Mode Control

Q5 Effect of disturbance on Sliding Mode Control.

Q6. Explain adaptive control in detail.

Practical Assessment

List of Experiments

Perform any 8 experiments using any simulation software:

1. Simulation of a lead or lag compensator for a given system and comparison of compensated and uncompensated systems responses.
2. Simulation of the closed-loop system with ideal real as nonlinearity.
3. Software program for determining a state-space model for a given transfer function and vice versa.
4. Software program for determining the state transition matrix.
5. Software program for checking the observability and controllability of a given system.
6. Simulation of state feedback control design using software.
7. Simulation of a full-order observer-based state feedback control system.
8. Effect of sampling and verification of sampling theorem by simulation.
9. Converting a continuous-time system to a discrete-time system and checking the response using the software.
10. Design of a linear quadratic regulator for a given system using simulation.

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Practical Assesment

Student Log Book

1. **Date**
2. **Exp. No.**
3. **Aim/Title**
4. **Apparatus**
5. **Ladder**
6. **Conclusion**

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Elective 1: PLC and SCADA

(403143A)

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Name of the Subject –PLC and SCADA: 403143A

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	25	125	03

Syllabus:

Unit 01: Introduction to PLC **(07 hrs)**

Role of automation in Industries, benefits of automation, Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers' Association), types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces), CPU, programmers and monitors, power supplies, selection criterion, advantages and disadvantages, specifications, comparison of various PLCs manufactured by Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.

Unit 02 Interfacing of PLC with I/O devices **(08 hrs)**

Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices Sensors-temperature, pressure, flow, level Actuators-Electrical, pneumatic, hydraulic EncodersIncremental, Absolute Transducers, Limit switches, proximity sensors Control Elements-Mechanical, Electrical, Fluid valves.

Unit 03 Programming of PLC **(08 hrs)**

Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of

ladder diagram Timer and counter- types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF, Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller.

Unit 04 Advance function and Applications of PLC (08 hrs)

Analog PLC operation and PLC analog signal processing, PID principles, typical continuous process control curves, simple closed loop systems, closed loop systems using Proportional, Integral and Derivative (PID), PID modules, PID tuning, tuning methods including the "Adjust and observe" method AC Motor Controls: AC Motor Starter, AC Motor Overload Protection, DC Motor Controller, Variable Speed (Variable Frequency) AC Motor Drive. PLC Applications in developing systems- Tank level controller using analog signals, temperature controller using RTD, speed control of electric motor.

Unit 05 -SCADA Systems (07 hrs)

Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system architecture, important definitions HMI, MTU, RTU, communication means, Desirable properties of the SCADA system, advantages, disadvantages, and applications of SCADA. SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS), System operating states, SCADA systems in critical infrastructure: Petroleum Refining Process, Conventional electric power generation, Water Purification System, Chemical Plant.

Unit 06 SCADA Protocols and Distributed Control Systems (07 hrs)

Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, DNP3 protocol, IEC 60870- 5-101 (IEC101), Control and Information Protocol (CIP), Ether 01111111111111Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus). Distributed Control System: Introduction to DCS- its working & operation, Architecture, Features, Advantages & Applications of DCS, Comparison between DCS & PLC.

Text Books:

[T1] John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi, 5th Edition
[T2] John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications", PHI Publishers.
[T3] Ronald L. Kurtz, "Securing SCADA Systems," Wiley Publishing.
[T4] Stuart A. Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised edition.
[T5] Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition.
[T6] Curtis Johnson, "Process Control Instrumentation Technology," Prentice-Hall of India.

Reference Books:

[R1] Gordan Clark, Deem Reynders, "Practical Modern SCADA Protocols," ELSEVIER
[R2] Batten G. L., "Programmable Controllers," McGraw Hill Inc., Second Edition BE Electrical (2019 Course) [R3] Bennett Stuart, "Real Time Computer Control," Prentice Hall, 1988
[R4] Krishna Kant, "Computer Based Industrial Control," PHI
[R5] P. K. Srivstava, "Programmable Logic Controllers with Applications," BPB Publications
[R6] Distributed Computer Control systems in Industrial Automation, D Popovic & Vijay Bhatkar.

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

Online Resources:

[O1] NPTEL Course: Electrical Measurement And Electronic Instruments By Prof. Avishek Chatterjee, Dept. of Electrical Engineering, IIT Kharagpur:- Web link https: // nptel.ac.in /courses /108 /105 / 108105153/
[O2] NPTEL Course: Industrial Instrumentation By Prof. Alok Barua, IIT Kharagpur:-Web linkhttps://nptel.ac.in/courses/108/105/108105064

Course Objectives

This course aims to:

1. To make the students understand the fundamentals of automation and various automation systems used in the industry, such as PLC
2. To provide knowledge levels needed for PLC programming and operating.
3. To develop the architecture of SCADA, explaining each unit in detail.
4. To apply knowledge gained about PLCs and SCADA systems to real-life industrial applications.

Course Outcomes:

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

CO1: Develop and explain the working of a PLC with the help of a block diagram.

CO2: Classify input and output interfacing devices with PLC.

CO3: Design PLC based application by proper selection criteria, developing GUI and ladder program.

CO4: Execute, debug, and test the programs developed for digital and analog operations.

CO5: Develop the architecture of SCADA and explain the importance of SCADA in critical infrastructure.

CO6: Describe the SCADA protocols and digital control systems, along with their architecture for automation.

Academic Activity Planner:

Units	**Unit Test1 (10marks)**	**Unit Test2 (10marks)**	**Assignment No:1 (10marks)**	**Assignment No:2 (10marks)**	**OBT : (10marks)**	**MCQ (10marks)**
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

Teaching Plan

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	Unit 01	Unit 01 Introduction to PLC	07
2	Unit 02	Interfacing of PLC with I/O devices	08
3	Unit 03	Unit 03 Programming of PLC	08
4	Unit 04	Unit 04 Advance function and Applications of PLC	08
5	Unit 05	Unit 05 SCADA Systems	08
6	Unit 06	Unit 06 SCADA Protocols and Distributed Control Systems	08

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Unit wise Lecture Plan

Unit No.-I: Introduction to PLC

Pre-requisites:-

- Basic concepts of Microprocessor, Microcontroller PIC microcontroller and different solid state memories.

Objectives:-

- To understand role of Automation industries.
- To study overall PLC system along with Input /Output modules and selection criteria for PLC

Outcomes:

- Understand Overall PLC system along with its merits and demerits

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Discussion: Syllabus, CO, PO, Vision, Mission of College and Department. Role of automation in Industries, benefits of automation,	T1,T2	Chalk and Talk
2	Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers' Association	T1,T2	Chalk and Talk
3	types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces),	T1,T2	Chalk and Talk
4	PLC Input and output modules (along with Interfaces), CPU,	T1,T2	Chalk and Talk
5	programmers and monitors, power supplies, selection criterion	T1,T2	Chalk and Talk
6	Comparison of various PLCs manufactured by	T1,T2	Chalk and Talk

	Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.		

Unit:1 Question Bank

1. What is PLC? What are the basic components of a PLC? Draw and explain the block diagram of PLC.
2. State the classification of PLC based on size and type.
3. Explain the operation of a PLC system.
4. What are the advantages and disadvantages of PLC?
5. State the need of automaton in the Industry.
6. List the advantages of PLC over conventional Relay logic.
7. Describe the classification of input / output module.
8. What is Sinking and Sourcing operation with reference to PLC I/O module?
9. Explain the functions of each sections of PLC CPU.
10. Describe the various types of solid state memory used in a PLC.
11. Describe the classification of input/ output module.
12. Describe the operation of Input module
13. Describe operation of output module
14. Explain how AC- in /DC- out power supply functions.
15. State the use of PLC.
16. List the various types of PLC.
17. State the purpose of input output interface.
18. Explain the operation flow chart of an output module
19. State advantages and disadvantages of output module
20. Write a note on Programming monitor

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Unit No.-II: Programming of PLC

Pre-requisites:-

- Principles of Digital logic design Operation of Relay

Objectives:-

- To provide knowledge levels needed for PLC programming and operating

Outcomes: -

- After successfully completing this unit students will be able:

Classify input and output interfacing devices with PLC

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Input ON/OFF switching devices, Input analog devices,	T1,T2	Chalk and Talk ,PPT
2	Output ON/OFF devices, Output analog devices Sensors-temperature,	T1,T2	Chalk and Talk ,PPT
3	pressure, flow, level Actuators-Electrical	T1,T2	Chalk and Talk ,PPT
4	pneumatic, hydraulic Encoders	T1,T2	Chalk and Talk ,PPT
5	Incremental, Absolute Transducers	T1,T2	Chalk and Talk ,PPT
6	Limit switches, proximity sensors	T1,T2	Chalk and Talk ,PPT
7	Control Elements- Mechanical, Electrical,	T1,T2	Chalk and Talk ,PPT
8	Control Elements- Mechanical, Electrical, Fluid valves	T1,T2	Chalk and Talk ,PPT

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UNIT:-II Question Bank

1. Explain Ladder diagram of PLC with one suitable example.
2. What are the standard steps involved in developing a ladder?
3. Describe the difference between legal and illegal PLC Ladder programming layouts
4. List the important considerations of program scanning rate and its effects
5. Explain PLC Timers along with their Timing Diagrams.
6. Draw Symbol , Write Truth table, and equivalent logic diagram of Different Logic gates
7. Draw the Ladder diagram for three motor having the following conditions
8. Draw the Ladder diagram for two motor having the following conditions
9. Blinking indicator lights are used in industry. Design a circuit in which two lights are flashed alternatively every 15secs
10. Make a program to turn a lamp ON after a specific time and then to turn a fan ON a fixed time after turning the lamp ON. Draw a ladder diagram for this system.
11. Write a program to show a counter that will count up to 4000.Draw a ladder diagram for this system.
12. Explain any three logical instructions in details with examples.
13. Explain any three Mathematical instructions in details with examples.
14. Explain any three Comparison instructions in details with examples.
15. Explain Necessity and Significance of SCP instruction.

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Unit No.-III: Programming of PLC

Pre-requisites:-

- Apply the concepts of digital logic to develop ladder diagram.
- Develop different logical functions like timer and counter using ladder diagram coding.
- To Study Advanced Instructions.

Outcomes: -

- After successfully completing this unit students will be able:
- Demonstrate ladder diagram coding using mimic diagram.
- Explain Arithmetic and logical instructions with various examples.
- To develop different ladder Programs using Various Instructions, Timer, Counter combination applicable to Various Industrial Processes.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Programming languages for PLC, Ladder diagram fundamentals,	T1,T2	Chalk and Talk
2	Rules for proper construction of ladder diagram Timer and counter- types along with timing diagrams,	T1,T2	Chalk and Talk
3	Timer and counter- types along with timing diagrams,	T1,T2	Chalk and Talk
4	Reset instruction, latch instruction MCR (master control relay) and control zones	T1,T2	Chalk and Talk
5	Developing ladder logic for Sequencing of motors, ON OFF, Tank	T1,T2	Chalk and Talk
6	level control, ON OFF temperature control	T1,T2	Chalk and Talk
`7	Elevator, bottle filling plant,	T1,T2	Chalk and
8	car parking, traffic light controller.	T1,T2	Chalk&talk

Unit No.-III : Question Bank

1. Explain any three temperature measurement Analog input devices
2. Describe basic input on/off switching system.
3. Describe operation of various types of input devices such as pushbutton, switches, selector switches and limit switches.
4. Describe the PLC output control motors and motor starters
5. Discuss output devices such as relays, solenoids and hydraulic cylinders.
6. Explain the various magnetic Transducers

Unit No.-IV: Advance function and Applications of PLC

Pre-requisites:-

- Basic knowledge of different sensors used for measurement of non- electrical parameters.
- Different motor starters, variable frequency drive, overload protection of AC motor

Objectives:-

- To Interface different sensors with PLC
- Measure and monitor different parameters of process using PLC.

Outcomes:-

- After successfully completing this unit students will be able to:
- Develop ladder logic for different applications like Tank level control, bottle filling plant etc
- Design ladder diagram coding for monitoring and control of different parameters of process

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Analog PLC operation and PLC analog signal processing,	T2,R1	Chalk and Talk
2	PID principles, typical continuous process control curves	T2,R1	Chalk and Talk
3	simple closed loop systems, closed loop systems using Proportional, Integral and Derivative (PID), PID modules,	T2,R1	Chalk and Talk
4	PID tuning, tuning methods including the “Adjust and observe” method	T2,R1,R7	Chalk and Talk
5	AC Motor Controls: AC Motor Starter, AC Motor Overload Protection,	T2,R1,R7	Chalk and Talk
6	DC Motor Controller, Variable Speed (Variable Frequency) AC Motor Drive.	T2,R1,R7	Chalk and Talk
7	PLC Applications in developing systems-	T2,R1	Chalk and

	Tank level controller using analog signals		Talk

Unit No.-IV Question Bank

1. Explain the basic parts of a simple closed loop control systems
2. Explain problems with simple closed loop control systems
3. Explain closed loop control systems using PID
4. Why motor starter is needed to control large AC motors.
5. Write note on AC motor overload protection
6. Explain in detail different types of speed control of DC Motor
7. How VFD operates to control speed of DC Motor State the purpose of input output interface.
8. Develop the ladder program for Sequencing of motors, Tank level control.
9. Develop the ladder program for ON/OFF temperature control and car parking.

Unit No.-V: Unit 05 SCADA Systems

Pre-requisites:-

- Basics of process control, Concept of Automation

Objectives:-

- Define SCADA system and explain its architectures.
- Explain the automation of interconnected power system.
- How SCADA can be implemented in critical infrastructures.

Outcomes:- After successfully completing this unit students will be able:

- Describe process automation in Industries using PLC and SCADA.
- Define & Explain SCADA system and its architecture.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction, definitions and history of Supervisory Control and Data Acquisition,	T3 & T4	Chalk and Talk, PPT
2	Typical SCADA system architecture, important definitions HMI, MTU, RTU, communication means,	T3 & T4	Chalk and Talk, PPT
3	Desirable properties of the SCADA system, advantages, disadvantages, and applications of SCADA.	T3 & T4	Chalk and Talk, PPT
4	SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture),	T3 & T4	Chalk and Talk, PPT
5	SCADA systems in operation and control of interconnected power system, functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS),	T3 & T4	Chalk and Talk, PPT

6	System operating states, SCADA systems in critical infrastructure: Petroleum Refining Process, Conventional electric power generation,	T3 & T4	Chalk and Talk, PPT
7	System operating states, SCADA systems in critical infrastructure: Water Purification System, Chemical Plant.	T3 & T4	Chalk and Talk, PPT

Unit No.-V : Question Bank

1. Explain with the help of block diagram SCADA system in detail. Give advantages and disadvantages of SCADA system.
2. Explain the various communication technologies used in SCADA system
3. Explain with a block diagram RTU and its use.
4. Compare SCADA,DCS and PLC based systems
5. Draw and explain various SCADA architectures with different advantages and disadvantages of each system.
6. Draw and explain SCADA Server.
7. Write note on SCADA system security issues.
8. Explain SCADA functions.
9. Explain desirable properties of SCADA system.
10. Write short note on Intelligent Electronic Devices (IED)
11. Explain in detail SCADA in substation automation.
12. Explain with block diagram use of SCADA in Energy Management system or interconnected power systems.
13. Explain with block diagram use of SCADA in oil and gas industries
14. Explain with block diagram use of SCADA in chemical plant.
15. Explain with block diagram use of SCADA in electrical power generation.
16. Explain with block diagram use of SCADA in Water Purification System.
17. Explain with block diagram use of SCADA in Petroleum Refining Process.
18. Compare PLC and SCADA systems in detail.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model,	T3&T4	Chalk and Talk, PPT
2	Modbus model, DNP3 protocol, IEC 60870- 5-101 (IEC101), Control and Information Protocol (CIP),	T3&T4	Chalk and Talk, PPT
3	Ether 01111111111111Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus).	T3&T4	Chalk and Talk, PPT
4	Distributed Control System: Introduction to DCS- its working & operation, Architecture , Features, Advantages & Applications of DCS, Comparison between DCS & PLC.	T3&T4	Chalk and Talk, PPT
5	Distributed Control System: Introduction to DCS- Features, Advantages & Applications of	T3&T4	Chalk and Talk, PPT

	DCS, Comparison between DCS & PLC.		
6	Comparison between DCS & PLC.	T3&T4	Chalk and Talk, PPT

Unit No.-VI: Unit 06 SCADA Protocols and Distributed Control Systems

Pre-requisites:-

- Scada Architecture, Concept of protocol

Objectives: -

- To understand various protocols used in SCADA
- Compare different protocols used for SCADA system
- Interface SCADA and PLC

Outcomes : -

- After successfully completing this unit, students will be able to
- Differentiate and compare different protocols used for SCADA system.
- Explain layered structure of SCADA protocols.

UNIT: VI : Question Bank

1) Explain seven layers of OSI Model and their functions.
2) Explain in details SCADA protocols.
3) Explain TCP/IP SCADA Protocols.
4) Explain Control and Information Protocol (CIP),
5) Explain Device Net Control Net and Flexible Function Block process (FFB)
6) Explain Flexible Function Block process (FFB)
7) Compare PLC and SCADA systems in detail
8) Draw and explain SCADA Server
9) Draw and explain IEC 61850 layered architecture
10) Write short note on the following

a) Seven layers of OSI model and their functions.
b) IEC 61850

c) DNP3

d) Control Net , Device Net, Ethernet/IP

e) FFB

f) Profibus

g) Control and Information Protocol

11) Explain security implementation of SCADA protocols.

12) Explain DCS considering Features, Advantages & Applications

13) Compare DCS & PLC

Practical Assessment

List of Experiments

1. Introduction to PLC
2. Interfacing of lamp & button with PLC for ON & OFF operation. Verify all logic gates.
3. Performed delayed operation of lamp by using push button.
4. UP/DOWN counter with RESET instruction.
5. Combination of counter & timer for lamp ON/OFF operation.
6. Set / Reset operation: one push button for ON & other push button for OFF operation.
7. PLC based temperature sensing using RTD.
8. PLC interfaced with SCADA & status read/command transfer operation.
9. Parameter reading of PLC in SCADA.
10. Alarm annunciation using SCADA.
11. Reporting & trending in SCADA system.
12. Temperature monitoring by using SCADA.

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Practical Assessment

Student Log Book

1. **Date**
2. **Exp. No.**
3. **Aim/Title**
4. **Apparatus**
5. **Ladder**
6. **Conclusion**

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DEPARTMENT OF ELECTRICAL ENGINEERING

HIGH VOLTAGE ENGINEERING

(403143C)

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Name of the Subject –Elective –III : High Voltage Engineering Code: 403149

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	25	150	03

Syllabus:

Unit 01: Breakdown in Gases:

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag for and factors on which time lag depends. (Numerical on Townsend's theory and Paschen's law).

Unit 02

1. Breakdown in Liquid Dielectrics: Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory.

2. **Breakdown in Solid Dielectrics:** Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, electromechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and electrochemical breakdown, Partial discharge(Internal discharge),Composite dielectric material, Properties of composite dielectrics, breakdown in composite dielectrics.

(Numerical on theories of liquid and solid dielectric materials)

Unit 03

Lightning and Switching Over Voltages

Lightning phenomenon, Different types of lightning strokes and mechanisms of lightning strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory.
Causes of over voltages and its effects on power systems, Over voltage due to switching surges and methods to minimize switching surges. Statistical approach of insulation coordination.

Unit 04

Generation of High Voltages and Current

Generation of high ac voltages-Cascading of transformers, series and parallel resonance system, Tesla coil. Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current .

Unit 05

Measurement of High Voltage and High Currents

Sphere gap voltmeter, electrostatic voltmeter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider, capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, Measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency a.c using current transformer with electro-optical signal converter, Radio interference measurements.

Unit 06

High Voltage Testing of Electrical Apparatus and H V Laboratories:

A) Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters.

B) Design, planning and layout of High Voltage laboratory:-Classification and layouts, earthing and shielding of H.V. laboratories.

Text Books:

1. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.
2. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publication Co. Ltd. New Delhi .

Reference Books:

1. E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi
3. Ravindra Arora, Wolf Gang Mosch, "High Voltage Insulation Engineering", New Age International Publishers Ltd. Wiley Estern Ltd.
4. High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel.
5. Subir Ray, "An Introduction to High voltage Engineering" PHI Pvt. Ltd. New Delhi

IS/IEEE Standards:

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

Prerequisite:

- Students should have knowledge of various classes of materials like solid, liquid, gaseous, conducting, insulating and resistive along with their basic characteristics.

Course Objective:

1) To make students able to explain the various breakdown processes in solid, liquid and gaseous materials and describe Lightning phenomenon, natural cause of overvoltage in detail with formation of charge in clouds.
2) To provide sound knowledge of Testing, Generation & measurement methods of DC, AC and impulse voltages and current.

3) To develop ability to carry out various testing procedures as per IS in laboratory with knowledge of earthing, safety and shielding of HV laboratory.

Course Outcomes:

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

Theory CO's

C404-IA.1A	Students will be able to explain various concepts of breakdown phenomenon of gaseous dielectric materials
C404-IA.2A	Student will be able to describe various concepts of breakdown phenomenon in liquid, solid & composite dielectrics
C404-IA.3A	Students will be able to recall concepts of various causes of overvoltages & can choose protective device
C404-IA.4A	Students will be able to categorize various methods of generation of High AC , DC and Impulse voltage
C404-IA.5A	Students will be able to classify various methods of measurement of High AC , DC and Impulse voltage
C404-IA.6A	Student will be able to design High Voltage Laboratory and demonstrate various test on High Voltage equipments

Practical CO's

C404-IA.1B	Students will be able to understand basic discrete time wave forms and Effect of sampling theorem.
C404-IA.2B	Students will be able to determine breakdown voltage of gas and liquid in uniform and non uniform field in presence of barrier.
C404-IA.3B	Students will be able to discuss Horn gap arrester, impulse current and voltage generator.
C404-IA.4B	Students will be able to summarize earthing/safety of HV installation lab/industry.

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Academic Activity Planner

Units	Unit Test1 (10marks)	Unit Test2 (10marks)	Assignment No:1 (10marks)	Assignment No:2 (10marks)	OBT : (10marks)	MCQ (10marks)
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

Teaching Plan:

Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Breakdown in Gases:	8 Hrs
2	II	Breakdown in Liquid Dielectrics Breakdown in Solid Dielectrics:	8 Hrs
3	III	Generation of High Voltages and Current:	8 Hrs
4	IV	Measurement of High Voltage and High Currents	8 Hrs
5	V	Lightning and Switching Over Voltages:	8 Hrs
6	VI	High Voltage Testing of Electrical Apparatus and H V Laboratories:	8 Hrs

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Unit wise Lecture Plan

Unit No.-I: Breakdown in Gases:

Pre-requisites:-

- Students should have knowledge of various basic classifications of gases.

Objectives:-

- To understand ionization process in Gases

Outcomes:-

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

- To explain ionization process in Gases

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Ionization process in gas, ,	T1, T2, R5	Chalk & Talk
2	Townsend's Theory, current growth equation in presence of primary ionization coefficients,		Chalk & Talk
3	current growth equation in presence of secondary ionization coefficients, limitations of Townsend's theory,		Chalk & Talk
4	Streamer mechanism of breakdown,		Chalk & Talk
5	Paschen's Law and its limitations		Chalk & Talk
6	Corona discharges for point plane electrode combination with positive and negative pulse application		Chalk & Talk
7	time lag for and factors on which time lag depends.		Chalk & Talk
8	Numerical on Townsend's theory and Paschen's law.		Chalk & Talk

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Question Bank: Theory

Unit :I

1. State and explain Townsend's first ionization coefficient.
2. Write short note on Townsend's breakdown criterion.
3. What do you mean by time lag?

   What are the factors which affects time lag?
4. Explain corona discharge.
5. Compare Between
   1) Uniform and Non-uniform field.
   2) Positive and Negative corona.

Unit No.-II: Breakdown in Liquid Dielectrics & Breakdown in Solid Dielectrics

Pre-requisites:-

- Students should have knowledge of different types of liquid & solid dielectric materials .

Objectives:-

- To understand breakdown process of different liquid & solid dielectric materials .

Outcomes:-

After successfully completing this unit students will be able:

- To explain breakdown process of different liquid & solid dielectric materials.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**1. Breakdown in Liquid Dielectrics:** Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid 2.	T1, T2	Power Point Presentation
2	breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory,		
3	Thermal mechanism of breakdown and Stressed Oil volume theory.		
4	Breakdown in Solid Dielectrics: Intrinsic breakdown: electronic breakdown		Power Point Presentation
5	avalanche or streamer breakdown, electromechanical breakdown, thermal breakdown,		
6	treeing and tracking phenomenon, Chemical and electrochemical breakdown,		
7	Partial discharge (Internal discharge),		
8	Composite dielectric material, Properties of composite dielectrics,		
9	breakdown in composite dielectrics.		Chalk & Talk

	(Numerical on theories of liquid and solid dielectric materials)		

Question Bank: Theory

Unit 2: Breakdown in Liquid Dielectrics & Breakdown in Solid Dielectrics

1. Explain:
   i. Cavitation and bubble theory.
   ii. Stressed oil volume theory.
   iii. Suspended particle theory
2. Explain properties of good transformer oil and its applications.
3. Explain treeing and tracking phenomenon.
4. Explain thermal breakdown process in case of solid insulating materials.
5. Explain properties of composite dielectric and state breakdown mechanism in composite dielectric.

Unit No.-III: Generation of High Voltages and Current:

Pre-requisites:-

- Students should have knowledge of basic circuits of HV & high current generation.

Objectives:-

- To learn new methods of HV & high current generation.

Outcomes:-

After successfully completing this unit students will be able to:

- To select method for HV & high current generation

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Generation of High Voltages and Current:** a) Generation of high ac voltages-Cascading of transformers,	T1, T2	Chalk & Talk
2	series and parallel resonance system,		Chalk & Talk
3	Tesla coil		Chalk & Talk
4	b) Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time,		Chalk & Talk
5	Generation of impulse current		Chalk & Talk
6	Multistage impulse generator,		Chalk & Talk
7	Modified Marx circuit,		Chalk & Talk
8	Tripping and control of impulse generators		Chalk &

			Talk
9	Generation of high impulse current.		Chalk

Question Bank: Theory

Unit 03: Generation of High Voltages and Current:

1. Explain principle of operation of multistageimpulse generator & describe any one tripping method.
2. With neat sketch explain Van- de- Graff generator.
3. Describe cascading transformer. What is its use?State its merits & demerits.

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Unit No.-IV: Measurement of High Voltage and High Currents:

Pre-requisites:-.

- Students should have knowledge of methods of current & voltage measurement.

Objectives:-

- To learn different methods of HV & high current measurement.

Outcomes:-

After successfully completing this unit students will be able to:

- To select different methods of HV & high current measurement.
-

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Measurement of High Voltage and High Currents:** Sphere gap voltmeter	T1, T2	Chalk & Talk
2	electrostatic volt meter, generating voltmeter, peak reading voltmeter		Chalk & Talk
3	resistive, capacitive and mixed potential divider, capacitance voltage transformer		Chalk & Talk
4	cathode ray oscilloscope for impulse voltage and current measurement,		Chalk & Talk
5	measurement of dielectric constant and loss factor,		Chalk & Talk
6	partial discharge measurements		Chalk & Talk
7	Measurement of high power frequency a.c using current transformer with electro-optical signal converter,		Chalk & Talk
8	Radio interference measurements.		Chalk & Talk

Question Bank:

Unit 04 : Measurement of High Voltage and High Currents:

1. Describe any one method of impulse current measurement.
2. Explain in detail electrostatic volymeter with neat diagram.
3. Explain method of using sphere gap for measurement of High Voltage.
4. Write short note on :
    i. RI measurement.
    ii. Parcial Discharge measurement.

Unit No.-V: Lightning and Switching Over Voltages:

Pre-requisites :-

- Students should have lightening basics & ligntening arrestors

Objectives :-

- To find causes of over voltages, lightning phenomenon, overvoltages.

Outcomes:-

After successfully completing this unit students will be able to:

- To select lightening arrester for diffrerent location.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Lightning and Switching Over Voltages:** Causes of over voltages, lightning phenomenon,	T1, T2	Power Point Presentation
2	Charge separation theories	T1, T2	Chalk & Talk
3	Different types of lightening strokes and mechanisms of lightening, strokes	T1, T2	Power Point Presentation
4	Wilson theory, Simpson theory,	T1, T2	
5	Reynolds and Mason theory,	T1, T2	
6	Over voltage due to switching surges	T1, T2	
7	methods to minimize switching surges.	T1, T2	
8	Statistical approach of insulation coordination	T1, T2	Chalk & Talk

Question Bank: Theory

Unit 5: Lightning and Switching Over Voltages

1. Explain in detail Reynold's and Mason's theory of charge formation in clouds.
2. Compare:
    1) Simpson and Wilson theory of charge formation in clouds.
    2) Horn gap LA with ZnO metal oxide LA
    3) Gap and gapless arrestor.
3. Explain various reasons for over voltage.
4. Explain remedial actions for switching surges.

Unit No.-VI: High Voltage Testing of Electrical Apparatus and H V Laboratories

Pre-requisites:-

- Students should have knowledge various basic tests on equipment.

Objectives: -

- To develop ability to test different equipment as per IS.

Outcomes:-

After successfully completing this unit, students will be able to:

- To develop ability to test different equipment as per IS in HV lab.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**High Voltage Testing of Electrical Apparatus and H V Laboratories:** A) Testing of insulators and bushings, testing,	T1, T2,R5	Power Point Presentation
2	Testing of Power capacitors and cables		
3	Testing of surge arresters		
4	B) Design, of High Voltage laboratory:- earthing and		
5	planning and layout of High Voltage laboratory,		
6	shielding of H.V. laboratories.		

Question Bank: Theory

Unit 6: High Voltage Testing of Electrical Apparatus and H V Laboratories:

1. Describe any three tests conducted on bushings.
2. State & explain classification of H.V. Laboratories.
3. Describe any one method of Partial Discharge measurement.
4. Write down specific characterictics of C.R.O. used for impulse voltage measurement.
5. With neat sketch describe electrostatic voltmeter with its advantages & disadvantages.
6. Describe any three tests conducted on insulator
7. Write short note on:

i. Grounding
ii. Earthing
iii. Fencing
iv. Shielding Of High Voltage laboratory.

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Practical Assessment

List of Experiments

Sr.No.	Name of the Practical
1	To perform breakdown test on transformer oil and obtain constants of breakdown voltage equation and breakdown strength
2	Measurement of unknown high A.C. voltage using sphere gap
3	To obtain breakdown strength of composite insulation system
4	Study of uniform and non uniform field in breakdown strength of air insulation system
5	To study surface flashover on corrugated porcelain/polymeric insulation system.
6	To perform experiment on horn gap arrestor and understand arc quenching phenomenon
7	To observe development of tracks and trees on polymeric insulation system
8	To Study effect of barrier on breakdown voltage of transformer oil.

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Alternate Energy System
(403144A)

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Name of the Subject – Renewable Energy Systems

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	02	-

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	25	125	4

Syllabus:

Unit I : Solar Thermal : 8Hrs

Solar radiation at the earth's surface, Solar constant, Spectral distribution, Extraterrestrial Radiation, Solar Terrestrial Radiation, Solar radiation geometry, Computation of cosθ for any location having any orientation, Empirical equations for predicting the availability of solar radiation: Monthly average daily and hourly global and diffuse radiation, Beam and Diffuse radiation under cloudless skies, Solar radiation on tilted surfaces : a)Beam radiation, b)Diffuse radiation, c)Reflected radiation, d)Flux on tilted surface.

Instruments for measuring solar radiation, Devices for thermal collection and storage, Thermal applications, Introduction to concentrating solar power (CSP) plants using technologies like a) Parabolic troughs b) Linear Fresnel reflector, c) Paraboloid Dish, etc.

Unit II: Solar Photovoltaic: 6 Hrs

Introduction to family of solar film technology, Single c-Si, Poly c-Si PV Cell, Module and Array, Array Design (factors influencing the electrical design of the solar array) : a) Sun Intensity, b)Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate, f) Electrical Load Matching, g) Sun Tracking, Peak Power Point Operation, Electrical characteristics of Silicon PV Cells and Modules, PV System Components, Efficiency of PV system, MPPT of solar system, PV system design for various applications(residential, commercial and industrial)

Unit III: Wind Energy System: 8Hrs

Power Contained in Wind, Thermodynamics of Wind Energy, Efficiency Limit for Wind Energy Conversion, Maximum Energy obtained for a Thrust-operated converter (Efficiency limit), Design of Wind Turbine Rotor, Power-Speed Characteristics, Torque-Speed Characteristics, Wind Turbine Control Systems: a) Pitch Angle Control, b) Stall Control, c) Power Electronics Control, d) Yaw Control, Control Strategy, Wind Speed Statistics, Statistical Wind Speed Distributions, Site and Turbine Selection, Extraction of wind energy and wind turbine power. Introduction to Offshore Wind Energy System and its comparison with Wind Energy System.

Unit IV : Biomass Energy Systems: 6 Hrs

Biomass Classification, Biomass Resources and their Energy Potential, Biomass Conversion Technologies: Anaerobic Digestion, Ethanol Fermentation, Biomass Gasification: Gasifiers, Fluidized Bed Gasifier, Biogas Technologies and their factor affecting Biogas Production, Biogas Plants: Floating and Fixed Dome type, designing of biogas plant, Introduction to Biodiesel**,** Power Generation from Municipal Solid Waste (MSW), Landfill Gas, Liquid Waste.

Unit V : Fuel Cell & Storage system: 8 **Hrs**

A. Fuel Cells: Operating principles of Fuel Cell, Fuel and Oxidant Consumption, Fuel Cell System Characteristics, Introduction to Fuel Cell Technology and its type, application and limits.

B. Storage systems: Hydrogen storage: Hydrogen production, relevant properties, Hydrogen as an Engine Fuel, methods of Hydrogen storage. Batteries: Introduction to Batteries, Elements of Electro-Chemical Cell, Battery classification, Battery Parameters, Factors affecting battery performance. Introduction to other storage technologies: pump storage, SMES, compressed air storage.

Unit VI : Integration and Economics of Renewable Energy System: 6Hrs.

Integration of RES with grid, Grid codes. Economics of RES: Simple, Initial rate of return, time value, Net present value, Internal rate of return, Life cycle costing, Effect of fuel Escalation, Annualized and levelized cost of energy.

Text Books:

1. S.P. Sukhatme, “Solar Energy”, Tata McGraw Hill
2. Chetan Singh Solanki, “Solar Photovoltaics-Fundamentals, Technologies and Applications”, PHI Second Edition
3. Godfrey Boyle, “Renewable Energy”, Third edition, Oxford University Press
4. H. P. Garg, J. Prakash, “Solar Energy-Fundamentals and Applications”, Tata McGraw hill Publishing Co. ltd., First Revised Edition.
5. Mukund R. Patel, “Wind and Power Solar System”, CRC Press
6. Gilbert M. Masters, “Renewable and Efficient Electrical Power Systems”, Wiley - IEEE Press, August 2004

Reference books:

1. D.P.Kothari, K.C.Singal, Rakesh Rajan, “Renewable Energy Sources and Emerging Technologies”, PHI
   Second Edition
2. Tapan Bhattacharya, “Terrestrial Solar Photovoltaics”, Narosa Publishing House.
3. Paul Gipe, “Wind Energy Comes of Age”, John Wiley & Sons Inc.
4. Donald L. Klass, “Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier, Academic Press
5. Thomas Ackermann, “Wind Power in Power Systems”, Wiley Publications.
6. B T.Nijaguna, “Biogas Technology”, New Age International Publishers.
7. Tony Burton, Nick Jenkins, David Sharpe, “Wind Energy HandBook-Second Edition”, John Wiley & Sons, Ltd., Publication

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

- www.e-booksdirectory.com
- onlinevideolecture.com/ebooks/?subject=Renewable%20Energy&level=4
- 3.www.solarenergy.org/.../solar-electric-handbook-photovoltaic-fundamentals-and-*appl*...

Course Objectives

- To develop a fundamental understanding of solar thermal and photovoltaic systems.
- To provide the knowledge of development and operation of wind energy system
- To discuss bio-energy resource assessment.
- To introduce different storage systems, Integration and Economics of Renewable Energy Systems.

Course Outcomes

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

- Analyze the performance of solar thermal and photovoltaic systems.
- Determine wind turbine performance.
- Explain and evaluate biomass resources in an Indian context.
- Illustrate the importance of storage systems.
- Analyze the economics of renewable energy sources.

Learning Outcome

Students will be able to

- Write theory of sources like solar, wind and also experiments of same.
- Analyze operating conditions like stand alone and grid connected of renewable sources,
- Reproduce different Storage Systems, concept of Integration and Economics of Renewable Energy System

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Academic Activity Planner

Units	Unit Test1 (10marks)	Unit Test2 (10marks)	Assignment No:1 (10marks)	Assignment No:2 (10marks)	OBT : (10marks)	MCQ (10marks)
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

Teaching Plan

Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Solar Energy-I	08
2	II	Solar Energy-II	06
3	III	Wind Energy	08
4	IV	Biomass Energy	06
5	V	Fuel Cells and Storage Systems	08
6	VI	Integration of RES	06

Unit wise Lecture Plan

Unit No.-I: Solar Energy-I

Pre-requisites:-

- Basic concepts and fundamentals of Solar Thermal systems.

Objectives :-

- To develop fundamental understanding about Solar Thermal systems.

Outcomes :

- Student can analyze the performance of solar thermal and photovoltaic systems.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Solar radiation at the earth's surface, Solar constant, Spectral distribution, Extraterrestrial Radiation,	T1, T2,R2	Chalk and Talk
2	Solar Terrestrial Radiation, Solar radiation geometry,	T1, T2,R2	Chalk and Talk
3	Computation of cosθ for any location having any orientation, Numericals	T1, T2,R2	Chalk and Talk
4	Empirical equations for predicting the availability of solar radiation: Monthly average daily and hourly global and diffuse radiation, Beam and Diffuse radiation under cloudless skies	T1, T2,R2	Chalk and Talk
5	Numericals on LAT, average radiation computation	T1, T2,R2	Chalk and Talk
6	Solar radiation on tilted surfaces : a)Beam radiation, b)Diffuse radiation, c)Reflected radiation, d)Flux on tilted surface.	T1, T2,R2	Chalk and Talk
7	Instruments for measuring solar radiation, Devices for thermal collection and storage	T1, T2,R2	Chalk and Talk

8	Thermal applications, Introduction to concentrating solar power (CSP) plants using technologies like a) Parabolic troughs b) Linear Fresnel reflector, c) Parabolic Dish, etc.	T1, T2,R2	Chalk and Talk

Question Bank: Theory

Unit :I

1) Explain the instruments used for measurement of solar radiation.
2) What are the different types of solar radiation?
3) Write empirical formulae for the monthly radiations. Write all the terms in them.
4) Define- a)declination angle b)azimuth angle c)slope d) latitude e) hour angle
5) Compare the difference in performance at different intensities.
6) Compare the difference in performance at different intensities under shadow effect.
7) What is LAT?
8) Explain the construction and working of Flat plate collector.

Unit No.-II: Solar Energy II

Pre-requisites:-

- Basic concepts and fundamentals of Solar Photovoltaic systems.

Objectives:-

- To provide knowledge about development of Photovoltaic systems and various operational as well as performance parameter/characteristics.

Outcomes:-

- Students can analyze the performance of solar thermal and photovoltaic systems.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to family of solar film technology, Single c-Si, Poly c-Si and Modules	T2, T3, R1	Chalk and Talk
2	Module and Array, Array Design (factors influencing the electrical design of the solar array) a) Sun Intensity, b)Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate	T2, T3, R1	Chalk and Talk
3	f) Electrical Load Matching, g) Sun Tracking, Peak Power Point Operation	T2, T3, R1	Chalk and Talk
4	PV Cell Electrical characteristics of Silicon PV Cells	T2, T3, R1	Chalk and Talk
5	PV System Components, Efficiency of PV system, MPPT of solar system, Numericals	T2, T3, R1	Chalk and Talk
6	PV system design for various applications(residential, commercial and industrial)	T2, T3, R1	Chalk and Talk

Question Bank: Theory

Unit 2:

1) Write a short note on factors affecting the electrical design of the solar array- 1) sun intensity 2) sun angle 3) temperature effect 4) electrical load matching
2) What is MPPT?
3) What is the difference between mono-crystalline Si PV module and multi-crystalline Si PV module?
4) What the difference in appearance of a crystalline silicon PV module and thin film PV module?
5) What is the difference in performance of a crystal Si PV module and a thin film PV module?
6) Show how PV modules are connected to supply 2 kW load. Draw a representative diagram.
7) Enlist the components used in a standalone PV system.
8) Define- a) short circuit current b) open circuit current c) Maximum power of PV module d) Fill factor e) module efficiency.

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Unit No.-III: Wind Energy

Pre-requisites:-

- Basic concepts of Wind Energy Conversion, design and various characteristics.

Objectives :-

- To provide knowledge about development of Wind Power plant and various operational as well as performance parameter/characteristics.

Outcomes:-

- Students can Determine wind turbine performance.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Power Contained in Wind, Thermodynamics of Wind Energy	T3,T5, R5	Chalk and Talk
2	Efficiency Limit for Wind Energy Conversion, Maximum Energy obtained for a Thrust-operated converter (Efficiency limit)	T3,T5, R5	Chalk and Talk
3	Design of Wind Turbine Rotor, Power-Speed Characteristics	T3,T5, R5	Chalk and Talk
4	Torque-Speed Characteristics	T3,T5, R5	Chalk and Talk
5	Wind Turbine Control Systems: a) Pitch Angle Control, b) Stall Control, c) Power Electronics Control, d) Yaw Control	T3,T5, R5	Chalk and Talk
6	Control Strategy, Wind Speed Statistics Wind Speed Distribution	T3,T5, R5	Chalk and Talk
7	Site and Turbine Selection, Extraction of wind energy and wind turbine power	T3,T5, R5	Chalk and Talk
8	Introduction to Offshore Wind Energy System and its comparison with Wind Energy System,	T3,T5, R5	Chalk and Talk

Question Bank: Theory

1) Compare the horizontal and vertical axis wind turbine.
2) Write the advantages and disadvantages of wind energy system.
3) What are the different types of wind generator?
4) Define- Yaw control and pitch control
5) Explain the various control strategies used in wind turbine system.
6) Draw Power-Speed Characteristics and Torque-Speed Characteristics for a wind generator.

Unit No.-IV: Biomass Energy

Pre-requisites:-

- Various classification of biomass, potential, conversion techniques.

Objectives:-

- To explain the contribution of Biomass Energy System in power generation

Outcomes:-

- Students can Explain and evaluate biomass resources in an Indian context.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Biomass Classification,and Biomass Resources and their Energy Potential	R3, R4	Chalk and Talk
2	Biomass Conversion Technologies: Anaerobic Digestion, Ethanol Fermentation,	R3, R4	Chalk and Talk
3	Biomass Gasification: Gasifiers, Fluidized Bed Gasifier,	R3, R4	Chalk and Talk
4	Biogas Technologies and their factor affecting Biogas Production,	R3, R4	Chalk and Talk
5	Biogas Plants: Floating and Fixed Dome type, designing of biogas plant	R3, R4	Chalk and Talk
6	Introduction to Biodiesel, Power Generation from Municipal Solid Waste (MSW), Land Fill Gas, Liquid Waste.	R3, R4	Chalk and Talk

Question Bank: Theory

1) What is biomass gasification?

2) What are the different gasifies? Write the advantages and disadvantages of different gasifiers.

3) What are the components of biomass plants?

4) List the factors affecting the biomass plant.

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Unit No.-V: Fuel Cell & Storage system

Pre-requisites:-

- Introduction of Fuel cell, characterisctics, storage system, details of batteries.

Objectives:-

- To teach different Storage systems, Integration and Economics of Renewable Energy System

Outcomes:-

- Students can compare the various storage sources for electrical energy.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Fuel Cells: Operating principles of Fuel Cell	R4	Chalk and Talk
2	Fuel and Oxidant Consumption, Fuel Cell System Characteristics	R4	Chalk and Talk
3	Introduction to Fuel Cell Technology and its type, application and limits.	R4	Chalk and Talk
4	Storage systems: Hydrogen storage: Hydrogen production, relevant properties, Hydrogen as an Engine Fuel, methods of Hydrogen storage.	R4	Chalk and Talk
5	Batteries: Introduction to Batteries, Elements of Electro Chemical Cell, Battery classification, Battery Parameters, Factors affecting battery performance.	R4	Chalk and Talk
6	Introduction to other storage technologies: pump storage, SMES, compressed air storage	R4	Chalk and Talk
7	Ruberics		

Question Bank: Theory

Unit No.-V

Theory Paper

1) Explain the working of fuel cell.
2) What are the different types of fuel cells? Explain each one in detail with necessary diagram.
3) How to maintain lead acid battery?
4) Write down the different methods of charging the battery.

Unit No.-VI: Integration and Economics of Renewable Energy System

Pre-requisites:-

- Basic Concepts of standards of renewable energy sources along with economic analysis

Objectives: -

- To teach different Storage systems, Integration and Economics of Renewable Energy System.

Outcomes:-

- Students can recognize the standards of renewable energy sources along with economic analysis and apply for evaluation of economic analysis.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Integration of RES with grid, standards.	R4	Chalk and Talk
2	Grid codes	R4	Chalk and Talk
3	Economics of RES: Simple, Initial rate of return	R4	Chalk and Talk
4	Time value, Net present value	R4	Chalk and Talk
5	Internal rate of return	R4	Chalk and Talk
6	Life cycle costing	R4	Chalk and Talk
7	Effect of fuel Escalation	R4	Chalk and Talk
8	Annualized and levelized cost of energy	R4	Chalk and Talk
9	Rubrics		

Question Bank: Theory

1) Explain-

   a) Initial rate of return, b) time value,c) Net present value, d) Internal rate of return, e) Life cycle costing ,f) Escalation,g) Annualized cost of energy h) levelized cost of energy.

2) List the factors required for synchronization of renewable source and Grid.

Practical Assessment

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List of Experiments

- Study of power quality monitor / analyzer
- Measurement of harmonic distortion of Desktop / computer and allied equipment
- Measurement of harmonic distortion of CFL or FTL with electronic ballast and magnetic ballast.
- Harmonic analysis of no load current of a single phase transformer
- Analysis of performance of three phase induction motor operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter
- Analysis of performance of single phase transformer operated with sinusoidal supply and under distorted supply conditions supplied by 1 phase inverter.
- Measurement of sag magnitude and duration by using digital storage oscilloscope
- Design of passive harmonic filter – computer simulation for power electronic application
- Design of active harmonic filter – computer simulation for power electronic application
- Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonic measurement (THD) by using MATLAB
- Power quality audit of institute or department

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Electric and Hybrid Vehicle

(403144B)

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Name of the Subject – Electric and Hybrid Vehicle: 403144B

Weekly Workload (in Hrs.)	Lecture	Tutorial	Practical
	03	01	00

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	25	125	4

Syllabus:

Unit 01 Li-ion Battery **07 hrs**

Materials used for Li-ion battery, Nanostructured Electrode Materials for Li-Ion Batteries, Li-ion battery protection, Wireless charging of EV, Life Cycle Assessment of Li-ion battery, Solid-state Battery, Panasonic 18650 & 2170 cell,

Unit 02 Battery Charging and Modelling **07 hrs**

TSCC/CV charging and CVCC/CC charging of Li-Ion battery, BMS standards, SoC Estimation methods (Kalman Filter, Neural Network, Fuzzy logic), Public EV charging stations, Solar Powered Charging Stations, Modeling of Lithium-ion batteries, Thermal Modeling of Li-ion battery.

Unit 03 Electric Vehicle Technologies **07 hrs**

Battery Swapping System, EV Fleet Management, Sensors for Electric Vehicles, Electric bus, Electric trucks, Fuel cell vehicles, Introduction of EV Subsystems and Configurations, Energy management strategies and its general architecture.

Unit 04 Plug-In Hybrid Electric Vehicles **07 hrs**

Hybridization of drivetrains in HEVs, Hybridization of energy sources in EVs, Power Flow control in hybrid drive train topologies, Power Management Strategies in HEV, Introduction of HEV Subsystem and Configurations, Vehicle Dynamics Fundamentals and HEV Modeling (Series Hybrid), Fuel efficiency analysis.

Unit 05 EV Components Design **07 hrs**

Criteria for battery selection , Forces on EV calculation, Power for EV calculation, Sizing the Power Converter, Sizing of Electric Machine for EVs and HEVs, Motor Torque Calculation, Induction motor control, PMSM motor control, Battery pack design, In vehicle networks- CAN

Unit 06 Electric Vehicle Policies and Startups **07 hrs**

FAME-II Policy , Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards , Star Labeling Schemes for Li-ion Packs- BEE India, EV Tariff, EV Startup examples, Li-ion Battery Recycling Policy and Standards.

Text Books:

[T1] Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau
[T2] Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011
[T3] Electric and Hybrid Vehicles by Tom Denton

Reference Books:

[R1] Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010
[R2] James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003..

Online Resources:

[O1] NPTEL Course : Electric Vehicles - Part 1 by Prof. Amit

Course objectives

This course aims to:

1. To gain knowledge of Li-ion battery protection.
2. To learn HEV Subsystems and Configurations.
. To understand Mathematical Model of Li-ion battery.

4. To familiarize with Hybridization of drivetrains.
5. To learn Star Labeling Schemes for Li-ion Packs.

Course Outcomes

This course aims to:

1. Students will be able to Explain Conventional Vehicle, Social and environmental importance of Electric and Hybrid vehicles.

2. Students will be able illustrate Energy Storage Systems, Hybridization of Energy storage, Drive train & energy storage technology in Electric and Hybrid Vehicles.

3. Students will be able to select charging algorithm, Battery balancing methods & Battery Management System.

4. Students will be able to explain architecture and performance of Electric and Hybrid Vehicles.

5. Students will be able to illustrate BLDC and Switched Reluctance Motor Drives for EVs & HEVs & Instrumentation and Control used for Electric & Hybrid Vehicles.

6. Students will be able to classify Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid energy systems.

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Academic Activity Planner

Units	Unit Test1 (10marks)	Unit Test2 (10marks)	Assignment No:1 (10marks)	Assignment No:2 (10marks)	OBT : (10marks)	MCQ (10marks)
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

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Teaching Plan

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	Unit 01	Li-ion Battery	07
2	Unit 02	Battery Charging and Modelling	07
3	Unit 03	Electric Vehicle Technologies	07
4	Unit 04	Plug-In Hybrid Electric Vehicles	07
5	Unit 05	EV Components Design	07
6	Unit 06	Electric Vehicle Policies and Start-ups	07

Unit wise Lecture Plan

Unit No.-I: Li-ion Battery

Prerequisites:-

- Basic concepts of Li-ion Battery

Objectives:-

- To understand role of Li-ion Battery
- To study overall Li-ion Battery and its working principle

Outcomes:

- Understand Overall Li-ion Battery along with its merits and demerits

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Discussion: Syllabus, CO, PO, Vision, Mission of College and Department. Role of automation in Industries, benefits of automation,	T1,T2	Chalk and Talk
2	Materials used for Li-ion battery and its composition. characteristics	T1,T2	Chalk and Talk
3	Nanostructured Electrode Materials for Li-Ion Batteries and its uses in EV industry	T1,T2	Chalk and Talk
4	Li-ion battery protection	T1,T2	Chalk and Talk
5	Wireless charging of EV, different types of wireless charging system	T1,T2	Chalk and Talk
6	Life Cycle Assessment of Li-ion battery ,Solid-state Battery,	T1,T2	Chalk and Talk

Unit:1 Question Bank

1. What are the basic components of a Li Battery? Draw and explain
2. State the classification of Li batteries on size and type.
3. Explain the operation of Li Batteries
4. What are the advantages and disadvantages of Li Batteries?
5. State the need of Li Batteries in the EV Industry.
6. List the advantages Solid State Batteries over conventional Li Batteries
7. Describe the classification of EV System
8. What is understood by self-discharge?
9. What is understood by complete discharge?
10. How long is the service life of batteries?
11. Describe the classification of Solid state batteries
12. Describe the operation of Permanent Magnet WCS
13. Describe operation of Static WCS
14. State the use of Wireless Charging
15. List the various types of Wireless Charging System.
16. Explain the operation Inductive WCS
17. State advantages and disadvantages of Solid State batteries

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Unit No.-II: Battery Charging and Modelling

Prerequisites:-

- Principles of Battery Charging and Modelling

Objectives:-

- To learn HEV Subsystems and Configurations.

Outcomes: -

- Describe the different types of Li-ion charging methods

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	TSCC/CV charging and CVCC/CC charging of Li-Ion battery,	T1,T2	Chalk and Talk ,PPT
2	BMS standards,	T1,T2	Chalk and Talk ,PPT
3	Soc Estimation methods (Kalman Filter, Neural Network, Fuzzy logic),	T1,T2	Chalk and Talk ,PPT
4	Public EV charging stations,	T1,T2	Chalk and Talk ,PPT
5	Solar Powered Charging Stations,	T1,T2	Chalk and Talk ,PPT
6	Modeling of Lithium-ion batteries,	T1,T2	Chalk and Talk ,PPT
7	Thermal Modeling of Li-ion battery	T1,T2	Chalk and Talk ,PPT

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UNIT:-II Question Bank

1. What is constant-voltage (CV) charging? constant-current-constant-voltage (CC-CV)
2. List the important considerations of CC and CV charging system
3. What is a wireless battery management system, working, benefits, and applications?
4. Difference between coulomb counting, Kalman filter, voltage method SoC estimation
5. What is thermal management in BMS?
6. How to estimate parameters for a cell model or equivalent circuit? one RC or two RC equivalent circuit
7. Active cell balancing of Li-ion Battery pack.
8. Difference between Kalman and Wiener Filtering

Unit No.-III: Electric Vehicle Technologies

Prerequisites:-

- Apply the concepts of Electric Vehicle Technologies.
- To Study Advanced Instructions

Objectives:

- To understand Mathematical Model of the Li-ion battery.

Outcomes: -

- Comprehend the knowledge of drivetrain hybridization.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Battery Swapping System	T1,T2	Chalk and Talk
2	EV Fleet Management,	T1,T2	Chalk and Talk
3	Sensors for Electric Vehicles Electric bus	T1,T2	Chalk and Talk
4	Fuel cell vehicles,	T1,T2	Chalk and Talk
5	Energy management strategies and its general architecture.	T1,T2	Chalk and Talk

Unit No.-III : Question Bank

1. Explain battery swapping system.
2. Describe EV Fleet Management
3. Describe operation of various types of Sensors for Electric Vehicles
4. Describe Electric bus and Electric trucks
5. Discuss Fuel cell vehicles with neat diagrams.
6. Explain EV Subsystems and Configurations.
7. What are Energy management strategies and its general architectur

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Unit No.-IV: Plug-In Hybrid Electric Vehicles

Pre-requisites:-

- Basic knowledge of Plug-In Hybrid Electric Vehicles.

Objectives:-

- To familiarize with Hybridization of drive trains.

Outcomes:-

- Evaluate EV motor sizing

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Hybridization of drivetrains in HEVs	T2,R1	Chalk and Talk
2	Hybridization of energy sources in EVs	T2,R1	Chalk and Talk
3	s Power Flow control in hybrid drive train topologies	T2,R1	Chalk and Talk
4	Power Management Strategies in HEV	T2,R1,R7	Chalk and Talk
5	Introduction of HEV Subsystems and Configurations,	T2,R1,R7	Chalk and Talk
6	Vehicle Dynamics Fundamentals and HEV Modeling (Series Hybrid)	T2,R1,R7	Chalk and Talk
7	Fuel cell efficiency analysis	T2,R1	Chalk and Talk

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Unit No.-IV Question Bank

1. Explain Hybridization of drivetrains in HEVs
2. Explain problems with Hybridization of drivetrains in HEVs
3. What is Hybridization of energy sources in EVs
4. Describe Power Flow control in hybrid drive train topologies
5. Write note Power Management Strategies in HEV
6. Explain in detail HEV Subsystems and Configurations
7. Explain Vehicle Dynamics Fundamentals and HEV Modelling
8. Explain is fuel cell efficiency analysis

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Unit No.-V: EV Components Design

Prerequisites:-

- Basics EV Components Design

Objectives:-

- To learn Star Labelling Schemes for Li-ion Packs.

Outcomes:-

- Classify Battery Recycling methods

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Criteria for battery selection and its functions	T3 & T4	Chalk and Talk, PPT
2	Forces on EV calculation, methods and application	T3 & T4	Chalk and Talk, PPT
3	Power for EV calculation methods, description and analysis	T3 & T4	Chalk and Talk, PPT
4	Sizing the Power Converter and its uses in EV system	T3 & T4	Chalk and Talk, PPT
5	Sizing of Electric Machine for EVs and HEVs , applications , functions	T3 & T4	Chalk and Talk, PPT
6	Motor Torque Calculation, tabulation, methods Induction motor control,	T3 & T4	Chalk and Talk, PPT
7	PMSM motor control, procedure, methods, calculations Battery pack design, In vehicle networks- CAN	T3 & T4	Chalk and Talk, PPT

Unit No.-V : Question Bank

1. Explain Criteria for battery selection
2. Explain Forces on EV calculation and its methods
3. Explain with a Power for EV calculation with the characteristics
4. What is Sizing the Power Converter? Explain
5. Compare the Sizing of Electric Machines for EVs and HEVs.
6. Explain Motor Torque Calculation.
7. Write note on Induction motor control and PMSM motor control
8. Explain Battery pack design.
9. Explain desirable properties of Battery pack design.
10. Write a short note on In vehicle networks- CAN.

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Unit No.-VI: Electric Vehicle Policies and Start ups

Prerequisites:-

- Scada Architecture, Concept of protocol

Objectives: -

- To understand various protocols used Electric Vehicle Policies and Start-ups

Outcomes : -

- After successfully completing this unit, students will be able to

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	FAME-II Policy and its description in detail	T3&T4	Chalk and Talk, PPT
2	Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards	T3&T4	Chalk and Talk, PPT
3	Star Labelling Schemes for Li-ion Packs- BEE India	T3&T4	Chalk and Talk, PPT
4	EV Tariff- description in detail. types	T3&T4	Chalk and Talk, PPT
5	EV Start-up examples with details.	T3&T4	Chalk and Talk, PPT
6	Li-ion Battery Recycling Policy and Standards	T3&T4	Chalk and Talk, PPT

UNIT: VI : Question Bank

1. Explain FAME-II Policy with details.
2. Explain in details Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards
3. Explain Star Labelling Schemes for Li-ion Packs- BEE India
4. Explain EV Tariff and its types.
5. Explain EV Start-up examples with details.
6. Explain Li-ion Battery Recycling Policy and Standards
7. What is the recycling policy?