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

TE – ELECTRICAL ENGINEERING

(SEMISTER-II)

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 tothe 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.

INDEX

Course Structure

Savitribai Phule Pune University

Savitribai Phule Pune University, Pune
Syllabus: Third Year (TE) Electrical Engineering (2019 course)
(w.e.f 2021-22)

SEMESTER-I

Course code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	SEM /PW /IN	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	SEM /PW /IN	Total
303141	Industrial and Technology Management	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303142	Power Electronics	3	4#	0	0	30	70	0	50	0	150	3	2	0	0	5
303143	Electrical Machines-II	3	2	0	0	30	70	25	25	0	150	3	1	0	0	4
303144	Electrical Installation Design and Condition Based Maintenance	3	4//	0	0	30	70	25	0	25	150	3	2	0	0	5
303145	Elective-I	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303146	Seminar	0	0	0	1	0	0	50	0	0	50	0	0	0	1	1
303147	Audit course-V	2*	0	0	0	0	0	0	0	0	0	GRADE: PP/NP				0
Total		**15**	**10**	**0**	**1**	**150**	**350**	**100**	**75**	**25**	**700**	**15**	**5**	**0**	**1**	**21**

303145: Elective-I

303145A : Advanced Microcontroller and Embedded System
303145B : Digital Signal Processing
303145C : Open Elective

303147 : Audit Course-V

303147A : Energy storage systems
303147B : Start-up & Disruptive innovation

SEMESTER-II

Course code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	SEM /PW /IN	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	SEM /PW /IN	Total
303148	Power System-II	3	2	1	0	30	70	25	50	0	175	3	1	1	0	5
303149	Computer Aided Design of Electrical Machines	3	4#	0	0	30	70	50	0	25	175	3	2	0	0	5
303150	Control System Engineering	3	2$	1$	0	30	70	25	0	25	150	3	1	0	0	4
303151	Elective-II	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303152	Internship	0	0	0	1	0	0	100	0	0	100	0	0	0	1	1
303153	Audit Course VI	2*	0	0	0	0	0	0	0	0	0	GRADE: PP/NP				0
Total		12	8	2	4	120	280	200	50	50	700	12	4	1	4	21

303151: Elective-II

303151A . IoT and its Applications in Electrical Engineering
303151B . Electrical Mobility
303151C: Cybernetic Engineering
303151D: Energy Management

303153 : Audit Course-VI

303153A. Ethical Practices for Engineers
303153B .Project Management

#Practical consists of Part A & part B. PART A; Regular experiments & part B; to bridge the gap between theory & actual industrial practices. For subject 303144; there will be auto cad drawing on Electrical installation, Electrical wiring, cabling etc. For 303149, Part A, Regular drawing by hand & part B same drawing by AutoCAD.
$ tutorial credit merged with Practical.
* Conduct over and above these lectures.

Power system- II
(303148)

Name of the Subject –Power system- II

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	01	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	50	-	25	178	05

Syllabus:

Unit 01: Performance of Transmission Lines

Evaluation of ABCD constants and equivalent circuit parameters of Long transmission line. Concept of complex power, power flow using generalized constants, surge impedance loading, Line efficiency, Regulation and compensation, basic concepts. Numerical based on: ABCD constants of Long transmission line, Power flow.

Unit 02: EHVAC Transmission

Role of EHV-AC transmission, standard transmission voltages, average values of line parameters, power handling capacity and line losses, phenomenon of corona, disruptive critical voltages, visual critical voltages, corona loss, factors and conditions affecting corona loss, radio and television interference, reduction of interference, Numerical Based on Corona, Corona loss and power handling capacity.

Unit 03: Per Unit System and Load Flow Analysis

Per unit system: Single line diagram, Impedance and reactance diagrams and their uses, per unit quantities, relationships, selection of base, change of base, reduction to common base, advantages and application of per unit system. Numerical based on network reduction by using per unit system. Load Flow Analysis: Network topology, driving point and transfer admittance, concept of Z-bus and formulation of Y-bus matrix using bus incidence matrix method, Numerical based on Y bus Matrix, power- flow equations generalization to n bus systems, classification of buses, Newton- Raphson method (polar method) Decoupled and Fast decoupled load flow (descriptive treatment only).

Unit 04: Symmetrical Fault Analysis

3-phase short-circuit analysis of unloaded alternator, sub-transient, transient and steady state current and impedances, D.C. Offset, and effect of the instant of short-circuit on the waveforms, estimation of fault current without pre-fault current for simple power systems, selection of circuit-breakers and current limiting reactors and their location in power system (Descriptive treatment Only) Numerical Based on symmetrical fault analysis.

Unit 05: Unsymmetrical Fault Analysis

Symmetrical components, transformation matrices, sequence components, power in terms of symmetrical components, sequence impedance of transmission line and zero sequence networks of transformer, solution of unbalances by symmetrical components, L-L, L-G, and L-L-G fault analysis of unloaded alternator and simple power systems with and without fault impedance. Numerical based on symmetrical components and unsymmetrical fault calculation.

Unit 06: HVDC Transmission

Classification and components of HVDC system, advantages and limitations of HVDC transmission, comparison with HVAC system, introduction to HVDC control methods - constant current, constant ignition angle and constant extinction angle control, HVDC systems in India, recent trends in HVDC system.

Text Books:

1. I.J. Nagrath and D.P. Kothari – Modern Power System Analysis – Tata McGraw Hill, New Delhi.
2. B R Gupta , “Power System Analysis and Design”, S. Chand.
3. Ashfaq Hussain, “Electrical Power Systems”, CBS Publication 5th Edition.
4. J. B. Gupta. “A course in power systems” S.K. Kataria Publications.
5. P.S.R. Murthy, “Power System Analysis”, B.S. Publications

References:

1. H. Hadi Sadat: Power System Analysis, Tata McGraw-Hill New Delhi.
2. G. W. Stagg and El- Abiad – Computer Methods in Power System Analysis – Tata McGraw Hill, New Delhi.
3. M. E. El- Hawary, Electric Power Systems: Design and Analysis, IEEE Press, New York.

4. Rakash Das Begamudre, "Extra High voltage A.C. Transmission Engineering", New age publication.
5. M. A. Pai, Computer Techniques in Power System Analysis, Tata McGraw Hill Publication.
6. Stevenson W.D. Elements of Power System Analysis (4th Ed.) Tata McGraw Hill, New
7. K. R. Padiyar: HVDC Transmission Systems, New Age International Publishers Ltd, New Delhi.
8. Olle I. Elgard – Electric Energy Systems Theory – Tata McGraw Hill, New Delhi.
9. V. K. Chandana, Power Systems, Cyber tech Publications.
10. P. Kundur, Power System Stability And Control, McGraw Hil

Reference Weblinks / Research Papers/ Referred book other than mentioned syllabus:

1. NPTEL Course on power system engineering:Debpriya Das https://nptel.ac.in/courses/108/105/108105104/
2. NPTEL Course on power system analysis By Dr. A.K. Sinha https://nptel.ac.in/courses/108/105/108105067/
3. NPTEL Course on power system analysis By Dr. Debpriya Das https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee72

Course Objectives: The course aims to learn

1) Develop analytical ability for Power system.
2) Introduce concept of EHVAC and HVDC System.
3) Demonstrate different computational methods for solving problems of load flow.
4) Analyze the power system under symmetrical and Unsymmetrical fault conditions.

Course Outcomes:

1. Students will be able to analyze power flow and performance of transmission line, line efficiency and compensation techniques.
2. Students will be able to solve problems involving power handling capacity, design and performance of EHVAC power transmission lines
3. Students will be able to categorize load flow solutions to various power system networks using per unit system by computational technique & software tools.

4. Students will be able to examine power system network under symmetrical fault and provide solutions considering protection of the transmission lines.
5. Student will be able to examine power system network under unsymmetrical fault and provide solutions considering protection of the transmission lines.
6. Students will be able to demonstrate knowledge of HVDC transmission systems and its control.

Practical

1. Students will be able to analyze power flow and performance of transmission line, line efficiency and compensation techniques for reactive power management.
2. Students will be able to examine power system network under symmetrical & unsymmetrical faults.
3. Students will be able to demonstrate knowledge of HVDC transmission systems and its control.
4. Students will be able to use Power system softwares viz. MATLAB, SCILAB for simulation and programming.

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	Performance of Transmission Lines	06
2	II	EHVAC Transmission	05
3	III	Per Unit System and Load Flow Analysis	07
4	IV	Symmetrical Fault Analysis	06
5	V	Unsymmetrical Fault Analysis	07
6	VI	HVDC Transmission	05

Unit wise Lecture Plan

Unit No.-I: Performance of Transmission Lines

Objective :-

- Develop analytical ability for Power system.

Outcome :

- Students will Solve problems involving modelling, design.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Evaluation of ABCD constants and equivalent circuit parameters of Long transmission line.	T1, T4 R1, R2, R3, R10	Board
2	Concept of complex power, power flow using generalized constants	T2,T5,T7,R2	Board
3	, surge impedance loading, Line efficiency	T2,T5,T7,R2	Board
4	Regulation and compensation, basic concepts.	T2,T5,T7,R2	Board
5	Numerical based on: ABCD constants of Long transmission line	T2,T5,T7,R2	Board
6	Power flow.	T2,T5,T7,R2	Board

Unit_I

Question Bank: Theory

Q. 1 a) A 132kV, three phase line has the following line parameters :
A = 0.98<3°, B = 110<75° ohms per phase. If the receiving end voltage is 132kV determine:
Sending end voltage and power angle if a load 50MVA at 0.8 p.f. (lagging) is being delivered at receiving end.

b) Explain the term compensation and what are different methods of compensation?

Q. 2 a) Derive equation for receiving end active and reactive power flow in the transmission line.

b) Explain the procedure for drawing the receiving end circle diagram.

Q. 3 a) Determine ABCD parameters of a long transmission line with 160km length having r = 0.1157 Ω /km,L = 0.00127 H/km and C=0.00875 μ F/Km.Assume frequency is 50Hz.

b) Explain surge impedance & surge impedance Loading.

Q. 4 a) Determine sending end complex power, of a transmission line delivering 50MVA at 132kV, 50Hz and 0.8 power factor lagging. The ABCD constants of transmission lines are A = D = 0.9855 ∠ 0.32°, B= 67.3 ∠ 68.69° Ω.

b) Write a short note on Complex power.

Q. 5 a) A three phase 132 kV overhead line delivers 60 MVA at 132 kV and power factor 0.85 lagging at its receiving end. The constants of line are A = 0.98, α = 3° and B = 110, β = 75° ohm per phase. Find
i) Sending end voltage and power angle.
ii) Sending end active and reactive power.

b) A 132kV three phase line has the following line constants :
A = 0.9 < 2.5°, B = 100 < 70° Ω, C = 0.0006 < 80° S.

Q. 6 **a)** Derive power flow equation for receiving end side of transmission line.

b) Derive ABCD constant in case of long transmission lines.

Q. 7 **a)** Determine sending end complex power, of a transmission line delivering 50MVA at 132kV, 50Hz and 0.8 power factor lagging. The ABCD constants of transmission lines are A = D = 0.9855 ‘0.32 , B = 67.3 ‘ 68.69 :.

b) A transmission circuit is represented by symmetrical network in which the series impedance is 120‘60 : and each shunt admittance is 2.5 x 10–3 ‘90 S .
i) Calculate value of general circuit constants ABCD
ii) the characteristic impedance of the circuit.

Q. 8 Prove the reactive power is proportional to voltage drop (Q α V)

Unit No.-II: EHVAC Transmission

Objectives:- Introduce concept of EHVAC

Outcomes:- After successfully completing this unit students will be able to performance evaluation of EHVAC power transmission lines..

Lecture No.	Details of the Topic to be covered	References	Mode of delivery
1	Role of EHV-AC transmission, standard transmission voltages,	T2 R3, R4	PPT
2	average values of line parameters, power handling capacity and line losses	T2 R3, R4	PPT
3	phenomenon of corona, disruptive critical voltages, visual critical voltages, corona loss, factors and conditions affecting corona loss	T2 R3, R4	PPT
4	radio and television interference, reduction of interference, Numerical Based on Corona	T2 R3, R4	PPT
5	Corona loss and power handling capacity	T2 R3, R4	PPT

Unit :II

Question Bank: Theory

1. Explain the phenomenon of corona and state factors affecting corona loss.
2. Find the disruptive critical voltage and visual critical voltage for local and general corona for a three phase line consisting of 21mm diameter conductors spaced in 6 m delta configuration. Take temperature 25° C, pressure 73 cm of mercury, surface factor 0.84, irregularity factor for local visual corona 0.72 and for general (decided) visual corona 0.82.
3. Explain power handling capacity and power loss at various voltage levels.
4. In three phase overhead line the conductors have each diameter of 30mm and are arranged in the form of an equilateral triangle. Assuming fair weather conditions air density factor is 0.95 and irregularity factor 0.95. Find the minimum spacing between the conductors if the disruptive critical voltage is not to exceed 230kV between lines. Breakdown strength of air may be assumed to be 30kV per cm (peak).

5. In three phase overhead line the conductors have each diameter of 30mm and are arranged in the form of an equilateral triangle.Assuming fair weather conditions air density factor is 0.95 and irregularity factor 0.95. Find the minimum spacing between the conductors if the disruptive critical voltage is not to exceed 230kV between lines. Breakdown strength of air may be assumed to be 30kV Per cm (peak).
6. Explain phenomena of corona in EHVtransmission lines
7. Estimate the corona loss per phase per km by using Peek's formula for three phase 110kV, 50Hz, 150km long transmission line consisting of three conductors each of 10mm diameter and spaced 2.5m apart in an equilateral triangle formation. The temperature of air is 30°C and the atmospheric pressure of 75mm of Hg.Take the irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30 kV.
8. What are factors and conditions affecting corona? Explain in detail
9. Estimate the corona loss per phase per km by using peek's formula for three phase 110kV, 50Hz, 150km long transmission line consisting of three conductors each of 10mm diameter and spaced 2.5 m apart in an equilateral triangle formation. The temperature of air is 30ºC and the atmospheric pressure of 75 mm of Hg. Take the irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30kV per cm (peak).
10. Explain phenomena of corona in EHVAC power transmission
11. Explain interference of radio and television signals in EHVAC transmission line
12. Derive the formula for critical disruptive voltage in corona
13. Explain the advantages and drawbacks of EHVAC transmission
14. Explain the phenomenon of corona and state various methods to reduce it
15. Find the disruptive critical voltage and visual critical voltage for local and general corona for a three phase line consisting of 21mm diameter conductors spaced in 6m delta configuration. Take temperature 25° C, pressure 73cm of mercury, surface factor 0.84, irregularity factor for local visual corona 0.72 and for general (decided) visual corona 0.82.

Unit No.-III: Per Unit System and Load Flow Analysis

Objectives :-

- Demonstrate different computational methods for solving problems of load flow..

Outcomes:-

After successfully completing this unit students will be able to:

- Students will Calculate per unit values and develop Y bus for solution power flow equations in power transmission networks.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Per unit system: Single line diagram, Impedance and reactance diagrams and their uses	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
2	per unit quantities, relationships, selection of base, change of base, reduction to common base, advantages and application of per unit system	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
3	Numerical based on network reduction by using per unit system	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
4	Load Flow Analysis: Network topology, driving point and transfer admittance	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
5	concept of Z-bus and formulation of Y-bus matrix using bus incidence matrix method	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
6	Numerical based on Y bus Matrix, power-flow equations generalization to n bus systems, classification of buses	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board
7	Newton- Raphson method (polar method) Decoupled and Fast decoupled load flow (descriptive treatment only).	T1, T3, T4 R1, R2, R3, R6, R8, R10	Board

Question Bank: Theory

Q. 1 What do you mean by p.u. system? Prove that the single phase and three phase values are same in p.u.

Q.2 Compare Newton Raphson method with Gauss Seidal method of load flow analysis.

Q.3 Derive YBUS matrix using singular transformation method for 'n' bus system.

Q.4 What is per unit system? Explain the advantages and applications of per unit system.

Q.5 Explain with flow chart Gauss Seidel method of load flow analysis.

Q.6 What are the advantages of per unit system? How the base impedance is converted to per unit system? What formula is to be used if base of per unit values is to be changed?

Q.7 Give in detail classification of bus for load flow analysis

Q.8 Derive static load flow equations for *n* bus system.

Q.9 Derive power flow equation for 'n' bus system.

Q.10 For the given power system reactances are shown in the fig. find bus admittance matrix [Y BUS]

Unit No.-IV: Symmetrical Fault Analysis

Objectives:-

- Analyze the power system under symmetrical and fault conditions

Outcomes:-

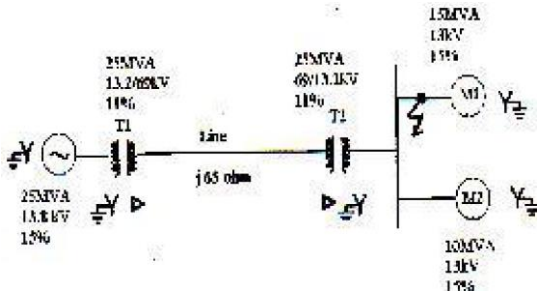
After successfully completing this unit students will be able to:

- Calculate currents and voltages in a faulted power system under both symmetrical and relate fault currents to circuit breaker ratings.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	3-phase short-circuit analysis of unloaded alternator, sub-transient	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board
2	transient and steady state current and impedances, D.C. Offset, and effect of the instant of short-circuit on the waveforms	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board
3	estimation of fault current without pre-fault current for simple power systems	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board
4	selection of circuit-breakers and current limiting reactors and their location in power system	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board
5	Numerical Based on symmetrical fault analysis	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board
6	Numerical Based on symmetrical fault analysis	T3, T4 R1, R2, R3, R6, R8, R9, R10	Board

Question Bank: Theory

Q. 1 A one line diagram of a three phase power system is shown in fig. A three phase short circuit fault occurs at point shown in fig. Choose 13.8k V, the generator voltage as the base voltage and 25MVA as the base MVA, Find fault current at fault location.



Q. 2 How the selection of circuit breaker is done in power system? What are the current limiting reactors? Explain its use in power system.

Q. 3 Explain the concept of sub transient, transient and steady state current and impedances of unloaded alternator under symmetrical fault condition.

Q. 4 What is current limiting reactor? Explain it with a suitable example.

Q. 5 Write a short note on Selection of Circuit breakers

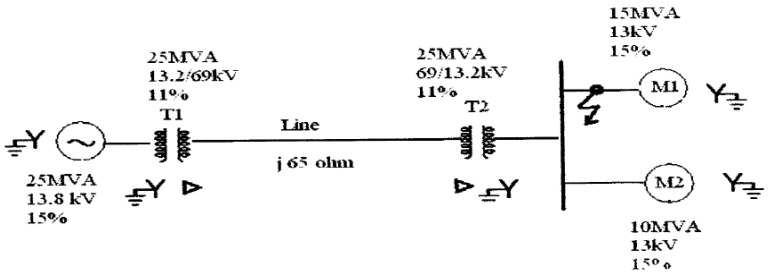
Q. 6 A delta connected load is connected to three phase supply. One line of supply is open. The current in other two lines is 20<0° A and 20<180° A Find symmetrical components of the line currents.

Q. 7 A 3-phase 11kV, 10MVA alternator have X0 = 0.05 pu, X1 = X2 = 0.15pu. It is on no load and rated terminal voltage. Find the ratio of the line currents for a single line to ground fault to three phase fault if (a) neutral is solidly grounded (b) neutral is grounded through Xn = 0.062pu.

Q.8 A three phase 11kV, 5MVA generator has a direct axis steady state reactance of 20%. It is connected to a 3MVA transformer having 5% leakage reactance and ratio of 11/33kV. The 33kV side is connected to a transmission line having 30ohm reactance. A three phase fault occurs at other end of transmission line. Calculate steady state fault MVA and current assuming no load prior to the fault. Take base of 11kV,5MVA on generator.

Q.9 A one line diagram of a three phase power system is shown in fig. A three phase short circuit fault occurs at point shown in fig. Choose 13.8kV, the generator voltage as the base voltage and 25MVA as the base MVA, Find fault current at fault

location


25MVA
13.2/69kV
11%
T1
25MVA
13.8 kV
15%
Line
j 65 ohm
25MVA
69/13.2kV
11%
T2
15MVA
13kV
15%
M1
M2
10MVA
13kV
15%

Unit No.-V: Unsymmetrical Fault Analysis

Objectives:-

- Analyze the power system under Unsymmetrical fault conditions

Outcomes:-

After successfully completing this unit students will be able to:

- Calculate currents and voltages in a faulted power system under asymmetrical faults and relate fault currents to circuit breaker ratings.

Lecture No.	Details of the Topic to be covered	References	Mode of delivery
1	Symmetrical components, transformation matrices	T3 R1, R2, R3, R6, R8	Board
2	sequence components, power in terms of symmetrical components	T3 R1, R2, R3, R6, R8	Board
3	sequence impedance of transmission line and zero sequence networks of transformer	T3 R1, R2, R3, R6, R8	Board
4	solution of unbalances by symmetrical components	T3 R1, R2, R3, R6, R8	Board
5	L-L, L-G, and L-L-G fault analysis of unloaded alternator and simple power systems with and without fault impedance.	T3 R1, R2, R3, R6, R8	Board
6	Numerical based on symmetrical components and unsymmetrical fault calculation	T3 R1, R2, R3, R6, R8	Board
7	Numerical based on symmetrical components and unsymmetrical fault calculation	T3 R1, R2, R3, R6, R8	Board

Question Bank: Theory

Q. 1 A 20 MVA, 11kV, Y connected synchronous generator is no load and rated voltage. If X1 = X2 = 12%, X0 = 6%. Estimate

i) Reactance Xn to limit SLG fault current, if the ratio of SLG fault current to three phase short circuit current is 1.

ii) LLG fault current with Xn in neutral grounding circuit

Q.2 For the three phase transmission line with self impedances Zs and mutual impedance ZM, show that Z1=Z2=ZS– ZM and Z0=ZS+ 2 ZM.

Q.3 Derive the expression for fault current in case of LLG fault considering the sequence network under this type of fault with suitable diagram.

Q.4 Draw zero sequence diagram for all types of combinations of transformer.

Q.5 Derive formula for fault current in case of LL fault.

Q.6 Derive formula for fault current in case of LLG fault.

Q.7 Show that fault current when L-L-G fault occurs at the terminals of solidly grounded star connected alternator. Draw the sequence network.

$$If = \frac{E}{X_1 \left(\frac{X_2 * X_0}{X_2 + X_0} \right)}$$

Unit No.-VI: HVDC Transmission

Objectives: - Introduce concept of HVDC System

Outcomes: -

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

- performance evaluation of HVDC power transmission lines

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Classification and components of HVDC system	T2, T3, T4 R3, R7, R9, R10	PPT
2	advantages and limitations of HVDC transmission, comparison with HVAC system	T2, T3, T4 R3, R7, R9, R10	PPT
3	m, introduction to HVDC control methods - constant current, constant ignition angle and constant extinction angle control	T2, T3, T4 R3, R7, R9, R10	PPT
4	HVDC systems in India	T2, T3, T4 R3, R7, R9, R10	PPT
5	recent trends in HVDC system	T2, T3, T4 R3, R7, R9, R10	PPT

Question Bank: Theory

Q. 1 Draw a single line diagram of HVDC transmission system and explain the component used

Q.2 Draw and describe Monopolar and Bipolar HVDC transmission systems with merits and Demerits

Q.3 Write short note on HVDC lines in India

Q.4 Give classification of HVDC transmission system in details

Q.5 Compare EHVAC and HVDC transmission

Q.6 Write various components if HVDC systems

Q.7 What are different control strategies used

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MODERN COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL

Practical Assessment

List of Experiments

Sr.No.	Name of the Practical
1	Measurement of ABCD Parameters of a Medium Transmission line with Magnitude and Angle
2	Measurement of ABCD Parameters of a Long Transmission line with Magnitude and Angle
3	Performance Study of Effect of VAR Compensation using Capacitor Bank for Transmission line
4	Plotting Receiving End Circle diagram using ABCD Parameters Circulated From Medium transmission Line
5	Formulation and Calculation of Ybus Matrix of a given System using Software
6	HVDC Simulation illustrate steady state and transient performance of 50MW HVDC Line
7	Static Measurement of Sub-transient Reactance of Salient Pole Alternator
8	Measurement of Sequence Reactance of a synchronous machine

Computer Aided Design of Electrical Machines (CADEM)

(303149)

Name of the Subject – (303149) Computer Aided Design of Electrical Machines (CADEM)

Weekly Work Load (in Hrs)	Lecture	Tutorial	Practical
	04	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	50	25	175	04+01

Syllabus:

Unit 01 Transformer Design: Part 1 (06 hrs)

Modes of heat dissipation. Heating and cooling curves. Calculations of heating and cooling time constants. Methods of cooling of transformer. Types and constructional features of core and windings used in transformer. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of three phase transformers as per IS 2026 (Part I). Introduction to computer aided design

Unit 02 Transformer Design: Part 2 (06 hrs)

Output equation with usual notations, optimum design of transformer for minimum cost and loss. Design of core, estimation of overall dimensions of frame and windings of transformer. Design of tank with cooling tubes.

Unit 03: Performance parameters of Transformer (6 Hrs.)

Estimation of resistance and leakage reactance of transformer. Estimation of no-load current, losses, efficiency and regulation of transformer. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Introduction to Computer aided design of transformer, generalized flow chart for design of transformer.

Unit 04: Three phase Induction Motor Design: Part I (6 Hrs.)

Specification and Constructional features. Types of ac windings. Specific electrical and magnetic loadings, ranges of specific loadings, Output equation with usual notations, Calculations for main dimensions, turns per phase, number of stator slots.

Unit 05: Three phase Induction Motor Design: Part II (6 Hrs.)

Suitable combinations of stator and rotor slots, Selection of length of air gap, factors affecting length of air gap, Design of rotor slots, size of bars, end rings for cage rotor and rotor slots, Conductor size, turns and area of cross section of conductor for wound rotor.

Unit 06: Performance parameters of Three Phase Induction motor (6 Hrs.)

Leakage flux and leakage reactance: Slot, tooth top, zig - zag, overhang. Leakage reactance calculation for three phase machines. MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on calculations of magnetizing current, calculations of no-load current. Calculations of losses and efficiency. Computer aided design of induction motor, generalized flow chart for design of induction motor.

Text Books:

[T1] M.G. Say – Theory and Performance and Design of A.C. Machines, 3rd Edition, ELBS London.

[T2] A.K.Sawhney – A Course in Electrical Machine Design, 10th Edition, - Dhanpat Rai and sons New Delhi.

[T3] K. G. Upadhyay- Design of Electrical Machines, New age publication

[T4] R. K. Agarwal – Principles of Electrical Machine Design, S. K. Katariya and sons.

[T5] Indrajit Dasgupta – Design of Transformers – TMH

Reference books:

[R1] K.L. Narang , A Text Book of Electrical Engineering Drawings, Reprint Edition : 1993 / 94 – Satya Prakashan, New Delhi.

[R2] A Shanmugasundaram, G. Gangadharan, R. Palani, - Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint 1988 - Wiely Eastern Ltd., - New Delhi

[R3] Vishnu Murti, “Computer Aided Design for Electrical Machines”, B.S. Publications.

[R4] Bharat Heavy Electricals Limited, Transformers - TMH.

UNIT	TEXT BOOKS	REFERENCE BOOKS
1	T1, T2, T4, T5	R1, R2, R4
2	T1, T2, T4, T5	R1, R4
3	T2, T5	R3, R4
4	T1, T2, T3, T4	R1,R2, R3

5	T2	R3
6	T2	R3

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

1. Transformers, Second Edition: Book by BHEL
2. https://operafea.com/transformer-design-software/transformer-design-opera-fea-10-minute-video-overview/
3. INTEGRATED Engineering Software (IES)

Course Objectives:

The course aims:-

1. Design of transformer based on specifications.
2. Determine performance based on the parameters of transformer.
3. Design of Induction motor based on specifications.
4. Determine performance based on the parameters of Induction motor.
5. Apply computer aided design techniques to transformer and induction motor design.

Course Outcomes:

Upon successful completion of this course,

The students will be able to:-

- Students will be able **to explain** constructional features of Transformer, modes of heat dissipations and IS 2026(Part I).
- Students will be able to **evaluate** main dimensions of transformer for minimum cost and minimum loss design, temperature rise and cooling scheme and resistance & leakage reactance
- Students will be able to **determine** the performance parameters, **calculate** mechanical force of transformer and **describe** Computer aided design of transformer.
- Students will be able **to develop** AC winding using modern tools and determine main dimensions of three phase induction motor.
- Students will be able **to design** stator, rotor & air gap and **calculate** unbalanced magnetic pull of three phase induction motor.

- Students will be able **to determine** various performance parameters of three phase induction motor and **Calculate** of short time and continuous rating of electrical machine.

Practical

1. Students will be able to evaluate main dimensions of transformer for minimum cost and minimum loss design, temperature rise and cooling scheme and resistance & leakage reactance
2. Students will be able to develop AC winding using modern tools and determine main dimensions of three phase induction motor.
3. Students will be able to design stator, rotor & air gap and calculate unbalanced magnetic pull of three phase induction motor.
4. Students will be able to determine various performance parameters of three phase induction motor and Calculate of short time and continuous rating of electrical machine.

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	Transformer	06
2	II	Transformer Design	08
3	III	Performance parameters of Transformer	08
4	IV	Three phase Induction Motor Design: Part I	08
5	V	Three phase Induction Motor Design: Part II	08
6	VI	Performance parameters of Three Phase Induction motor	06

Unit wise Lecture Plan

Unit No.-I: Transformer Design: Part 1

Pre-requisites:-

- Basic knowledge of Transformer

Objectives:-

- To understand the modes of heat dissipations and IS 2026(Part I).
- To gain knowledge of Transformer constructions, auxiliaries.

Outcomes:-

After successfully completing this unit students will be able:

- Understand the heat dissipation in electrical machines and analyze its relation to the rating of the machine.
- Explain the transformer constructions, and its auxiliaries & their functions.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Modes of heat dissipation; Heating and cooling curves,	T1, T2, T4, T5 R1, R2, R4	Chalk and talk
2	Calculations of heating and cooling time constants.		Chalk and talk
3	Calculations of short term ratings.		Chalk and talk
4	Types and constructional features of core and windings used in transformer		Chalk and talk and PPT
5	Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator.		Chalk and talk and PPT
6	Specifications of three phase transformers as per IS 2026 (Part I).		Chalk and talk and PPT

Question Bank: Theory

Q.1 Explain different modes of heat dissipation in an electrical machine.

Q.2 Explain heating and cooling curves of electrical machine and based on it define the heating time constant and cooling time constant. (Relevant numerical problems)

Q.3 Explain short term rating of an electrical machine. (Relevant numerical problems)

Q.4 Which are the different types of windings used in transformer? Explain with labeled diagram.

Q.5 Explain tap changer, pressure release valve, breather and conservator, along with their function.

Q.6 Which are the Specifications of three phase transformers as per IS 2026 (Part I)..

Unit No.-II: Transformer Design: Part 2

Pre-requisites:-

- Basic knowledge of **Transformer** .

Objectives:-

- To design transformer.
- To understand determination of parameters of transformer.

Outcomes:-

After successfully completing this unit students will be able:

- To calculate core and main dimensions of a transformer.
- To understand and determine the performance parameters of a transformer.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Output equation with usual notations,	T1, T2, T4, T5 R1, R4	Chalk and talk
2	Optimum design of transformer for minimum cost and loss. Related numerical problem.		Chalk and talk, PPT
3	Design of main dimensions, core, yoke and windings of transformer.		Chalk and talk, PPT
4	Design of main dimensions, core, yoke and windings of transformer. Related numerical problem		Chalk and talk, PPT
5	Methods of cooling and tank design. Related numerical problem		Chalk and talk, PPT
6	Estimation of resistance of transformer.		Chalk and talk
7	Estimation of leakage reactance of transformer.		Chalk and talk, PPT
8	Design related numerical problem		Chalk and talk, PPT

Question Bank: Theory

Q.1 Derive the output equation of three phase transformer.

Q.2 What is an optimum design? Derive the equation for the optimization of cost during design.

Q.3 Design a cooling scheme for the transformer so as to maintain the temperature within specified limit.

Q.4 How to estimate the resistance of a three phase transformer?

Q.5 How to determine the leakage reactance of a three phase transformer?

- Numerical problems related to the above points.

Unit No.-III: Performance parameters of Transformer

Pre-requisites:-

- Basic knowledge of **Transformer and its operation**

Objectives:-

- To estimate Performance parameters of Transformer
- To understand Computer aided design of transformer and generalized flow chart for design.

Outcomes:-

After successfully completing this unit students will be able to:

- Estimation of no-load current, losses, efficiency and regulation of transformer
- Calculation of mechanical forces developed under short circuit conditions
- Prepare generalized flow chart for design of transformer

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Estimation of resistance of transformer. Estimation of leakage reactance of transformer		Chalk and talk, PPT
2	Estimation of leakage reactance of transformer	T3, T5 R3, R4	Chalk and talk, PPT
3	Derive the expression for estimation of no-load current, Numerical problems related to estimation of no-load current,		Chalk and talk, PPT
4	Estimation of losses, efficiency and regulation of transformer.		Chalk and talk, PPT
5	Numerical problem related to estimation of losses and efficiency		Chalk and talk
6	Leakage flux and mechanical forces developed in a transformer		Chalk and talk, PPT
7	Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect.		Chalk and talk, PPT

8	Introduction to Computer aided design of transformer, generalized flow chart for design of transformer.		PPT

Question Bank: Theory

Q.1 Derive the expression for the estimation of no-load current

Q.2 Explain leakage flux and different forces developed in a transformer.

Q.3 Derive the expression for different forces developed in a transformer under short circuit conditions,

Q.4 Which are the measures taken to overcome the effect of the forces developed in a transformer?

Q.5 What is Computer aided design of transformer, draw generalized flow chart for design of transformer.

Numerical problems related to the above points.

Unit No.-IV: Three Phase Induction Motor Design: Part I

Pre-requisites:-

- Basic Knowledge of **working of three phase Induction Motor**

Objectives:-

- To develop AC winding using modern tools
- Define different terminology of three phase induction motor.
- Determine main dimensions and design stator of three phase induction motor

Outcomes:-

After successfully completing this unit students will be able to:

- develop AC winding using modern tools
- understand constructional detail and material used in three phase induction motor
- determine main dimensions and
- design stator of three phase induction motor

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Specification and Constructional features of three phase induction motor	T1, T2, T3, T4, R1,R2, R3	Chalk and talk, PPT
2	Study and design of lap type ac windings.		Chalk and talk, PPT
3	Study and design of wave type ac windings.		Chalk and talk, PPT
4	Study and design of hemitropic and whole coil ac windings.		Chalk and talk, PPT
5	Study and design of mush type ac windings.		Chalk and talk, PPT
6	Specific loadings and their ranges, selection of specific loadings		Chalk and talk, PPT
7	Output equation with usual notations, Numerical problems		Chalk and talk,

8	turns per phase, number of stator slots.		Chalk and talk, PPT
9	Numerical problems		Chalk and talk,

Question Bank: Theory

Q.1 With suitable diagram explain difference in Lap winding and Wave winding.

Q.2 Explain different types of induction motor and their salient features

Q.3 What are the specific loading of the machine?

Q.4 Write the range of the values of specific magnetic loading and specific electric loading in three phase induction motor.

Q.5 Explain the effect of the values of specific magnetic loading and specific electric loading on the design of three phase induction motor.

Unit No.-V: Three Phase Induction Motor Design: Part II

Pre-requisites:-

- Basic Knowledge of working of three phase Induction Motor

Objectives:-

- To design rotor of three phase induction motor
- To study factors affecting length of air gap

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

- design rotor of three phase induction motor
- To study factors affecting length of air gap
- To calculate unbalanced magnetic pull in 3 phase induction motor.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Design of the stator: selection of no. of slots	T2, R3	Chalk and talk, PPT
2	Suitable combinations of stator and rotor slots, their effect		Chalk and talk, PPT
3	Calculations for main dimensions and stator design parameters.		Chalk and talk, PPT
4	Selection of length of air gap, factors affecting length of air gap, unbalanced magnetic pull		Chalk and talk, PPT
5	Numerical problems,		Chalk and talk, PPT
6	Design of rotor slots, size of bars, end rings for cage rotor and rotor slots,		Chalk and talk, PPT
7	turns and area of cross section of conductor for wound rotor		Chalk and talk,
8	Numerical problems		Chalk and talk,

Question Bank: Theory

Q.1 Derive the output equation for a three phase induction motor.

Q.2 List the steps to design the stator of three phase induction motor.

Q.3 List the steps to design the rotor of three phase induction motor.

Q.4 Which are the suitable combination of the no. of the slots for stator and rotor?

Q.5 Explain the phenomenon of crawling and cogging of three phase induction motor

Q.6 What is an unbalanced magnetic pull? Write the causes and its effects.

Unit No.-VI: Performance parameters of Three Phase Induction motor

Pre-requisites:-

- Basic knowledge of design and operation of induction motor

Objectives: -

- To calculate performance parameters of Three Phase Induction motor
- To calculate short time and continuous rating of electrical machine.

Outcomes:-

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

- To calculate performance parameters of Three Phase Induction motor
- To determine short time and continuous rating of electrical machine

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Leakage flux and leakage reactance: Slot leakage	T2, R3	Chalk and talk, PPT
2	tooth top leakage, zig-zag leakage, overhang leakage		Chalk and talk, PPT
3	Numerical problems		Chalk and talk, PPT
4	leakage reactance calculation for three phase machines		Chalk and talk, PPT
5	Numerical problems		Chalk and talk, PPT
6	MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation,		Chalk and talk,

	effects of ducts on calculations of magnetizing current, calculations of no-load current.		PPT
7	Calculations of losses and efficiency.		Chalk and talk,
8	Calculation of short time and continuous rating of electrical machine.		Chalk and talk,

Question Bank: Theory

Q.1 Which are the different types of leakage reactance in a three phase Induction motor?

Q.2 Write down the procedure for the calculation of tooth top leakage reactance, zig-zag leakage reactance, overhang leakage reactance.

Q.3 What is the effect of ducts on calculations of magnetizing current?

Q.4 Write down the procedure for MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core.

Q.5 How to calculate the no load current of the three phase induction motor?

Q.6 How to calculate the losses and efficiency of a three phase induction motor?

Q.7 What is short term rating of an electrical machine?

List of Practical's

1. Details and assembly of three phase transformer with design report.(Sheet in CAD)
2. Details and layout of AC winding with design report.(Sheet in CAD)
3. Assembly of 3-phase induction motor.(Sheet optional CAD or Drawing)
4. Use of Finite Element Analysis(FEA) software for analysis of electrical machines, the report
5. Report on industry visit

Mapping of Practical's with CO's

Sr. No.	Experiment Title	CO-1	CO-2	CO-3	CO-4	CO-5	CO-6
1	Assembly of three phase transformer with design	2	3	3			
2	Layout of AC winding with design				3		
3	Assembly of 3-phase induction motor				3	3	1
4	Finite Element Analysis(FEA) software for analysis of electrical machine	2	2	3	2	2	3
5	Report on industry visit	3	3	3			

Note: Linking of Practical's with CO should be graded as follows:

Slightly (SL) =1 Moderately (M) =2 Substantially (SB) =3

Control System Engineering (303150)

Name of the Subject – Control System-I

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	3	1	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	25	150	5

Syllabus:

Unit I General **08Hrs**

Basic concepts of control system, classification of control systems, types of control system: feedback, tracking, regulator system, feed forward system, transfer function, concept of pole and zero, modeling of Electrical and Mechanical systems (Only series linear and rotary motion) using differential equations and transfer function , analogy between electrical and mechanical systems, block diagram algebra, signal flow graph, Mason's gain formula.

Unit II Time domain analysis **08Hrs**

Concept of transient and steady state response, standard test signals: step, ramp, parabolic and impulse signal, type and order of control system, time response of first and second order systems to unit impulse, unit step input, time domain specifications of second order systems, derivation of time domain specifications for second-order under-damped system for unit step input, steady state error and static error coefficients.

Unit III Stability analysis and Root Locus **08Hrs**

Concept of stability: BIBO, nature of system response for various locations of poles in S-plane. Routh-Hurwitz criterion. Root Locus: Angle and magnitude condition, Basic properties of root locus. Construction of root locus, Stability analysis using root locus.

Unit IV Frequency domain analysis-I **08Hrs**

Introduction, Frequency domain specifications, correlation between time and frequency domain specifications, polar Plot, Nyquist plot, stability analysis using Nyquist plot.

Unit V Frequency domain analysis -II **08Hrs**

Introduction to Bode plot, Asymptotic approximation: sketching of Bode plot, stability analysis using Bode plot.

Unit VI PID controllers **06Hrs**

Basic concept of P, PI, PID controller, design specifications in time domain and frequency domain. design of PID controller by Root Locus, tuning of PID controllers using Ziegler-Nichol Methods Control System Components: Working principle and transfer function of Lag network, lead network, potentiometer, DC servo motors

Text Books

1. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers, 4thEdition, 2006.
2. Katsuhiko Ogata, "Modern control system engineering", Prentice Hall, 2010.
3. B. C. Kuo, "Automatic Control System", Wiley India, 8th Edition, 2003.
4. Natarajan Ananda, Babu P. Ramesh "Control Systems Engineering" , Second Edition, Scitech Publication, 2010

Reference Books

1. Richard C Dorf and Robert H Bishop, "Modern control system", Pearson Education, 12th edition,2011.
2. Nise N. S. "Control Systems Engineering", John Wiley & Sons, Incorporated, 2011
3. Jacqueline Wilkie, Michael Johnson, Reza Katebi, "Control Engineering: An Introductory
4. Course", Palgrave Publication, 2002.
5. D. Roy Choudhary, "Modern Control Engineering", PHI Learning Pvt. Ltd., 2005.
6. Smarajiti Ghosh, "Control Systems : Theory and Applications" , Dorling Kindersley (RS), 2012.

Course Objectives:

- To understand basic concepts of the classical control theory.
- To model physical systems mathematically.
- To analyze behaviour of system in time and frequency domain.
- To design controller to meet desired specifications.

Course Outcomes:

After successfully completing the course:

CO1 Students will be able to determine control system parameters and physical system

CO2 Students will be able to evaluate the behaviour of control system by time domain specifications and using modern tool.

CO3 Student will be able to demonstrate stability of system in time domain.

CO4 Student will be able to determine stability of system using Polar and Nyquist Plot in frequency domain.

CO5 Student will be able to determine stability of system using Bode Plot in frequency domain.

CO6 Student will be able to select PID controller tunning parameters for desired performance specification.

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	General	8
2	II	Time domain analysis.	8
3	III	Stability analysis and Root Locus	8
4	IV	Frequency domain analysis-I	8
5	V	Frequency domain analysis-II	8
6	VI	PID controllers	8

Unit wise Lecture Plan

Unit No.-I: General.

Pre-requisites:-

- Laplace Transform, ordinary differential equations.

Objectives:-

- To understand basic concepts of the classical control theory
- To model physical systems mathematically.

Outcomes:

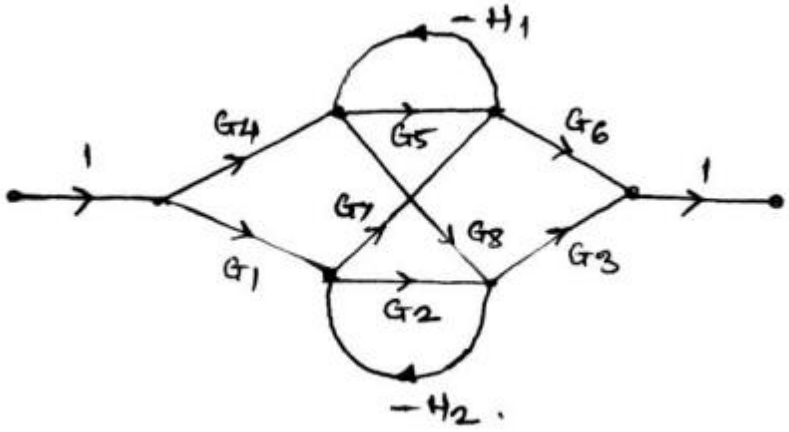
- Students will demonstrate and determine control system parameters and model the physical system.
- Student can list, categorize and model control system components.

Lecture No.	Details of the Topic to be covered	References
1	Basic concepts of control system, open loop, close loop, classification of control systems.	T1,R1,R2
2	Types of control system: Feedback, tracking, regulator system, feed forward system.	T1,T2,R3
3	Transfer function, Pole and zero concept. Modelling and representation of control system-Basic concept.	T3,R1,R3
4	Mechanical, Electrical and equivalent system.	T1,T3,T4,R5
5	Block diagram reduction	T2,T3,T4
6	signal flow graph	T1,T2,R1,R2
7	Mason's gain formula.	T1,R1,R2
8	Rubrics	

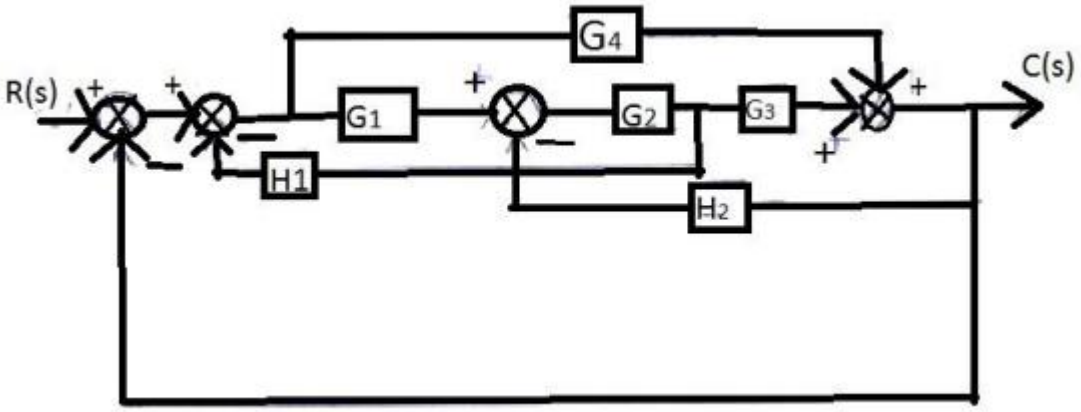
Unit 1

Q 1 .Discuss feedback characteristics of control system in respect of i) sensitivity ii) disturbance signal iii) system gain and iv) system stability

Q2 Using Mason's gain formula find the gain of the following system shown in



Q3.Find the transfer function for the system shown in Fig. 2 using Mason's Gain Formula.



Q4 .With suitable example distinguish

i)Linear control system and Non-Linear control system

ii)Open loop and closed loop control system

Q5 Obtain transfer function of a R-L-C series ckt excited by a voltage source.

Unit No.-II: Time domain analysis

Objectives:-

- To analyze behavior of system in time domain.

Outcomes:-

After successfully completing this unit students will be able to:

- Students can analyze and evaluate the behavior of control system by time domain specifications and validate it by modern tool.
-

Lecture No.	Details of the Topic to be covered	References
1	Standard test signal –step, ramp, parabolic and impulse signal, type and order of control system	T1,T3,R1
2	time response of first and second order systems to unit step input, steady state errors – static and dynamic errors coefficients	T1,T3,R1
3	Generalized errors series method.	T1,T3,R1
4	Time domain specifications of second order systems.	T1,T3,R1
5	Dominant closed loop poles of higher order systems	T1,T3,R1
6	Design specifications in time domain.	T1,T3
7	static and dynamic errors coefficients	T1,T3
8	Rubrics	

Q1 For a unity feedback system having open loop transfer function [5]

$$G(s) = \frac{K(s+2)}{s(s^3 + 7s^2 + 12s)}$$

Find :

1) Type of the system
2) Static error coefficients
3) Steady state error for an input $\frac{R}{2}t^2$.

Q2 Determine time response specifications for $G(s) = \frac{10}{s^2+2s+6}$ with unity feedback. [5]

Q. 3 What are standard test signals used in time domain analysis. Derive steady state errors and static error, coefficients for type '0', type '1' and type '2' systems. [5]

Q4 'or a system with $G(s)H(s) = \frac{5}{S+5}$, calculate the generalised error oefficients and steady state error. The input to the system is r(t) = 6 + 5t.

Unit No.-III: Stability analysis and Root Locus

Objectives:-

- To analyze behavior of system in time and frequency domain.

Outcomes: -

After successfully completing this unit students will be able to:

- Students can analyze and evaluate the behavior of control system by time domain specifications and validate it by modern tool.
- Student can implement the stability analysis in frequency and time domain.

Lecture No.	Details of the Topic to be covered	References
1	Concept of stability-Absolute, relative and marginal.	T1,T3,R1
2	Nature of system response for various locations of roots in S plane of characteristics equation.	T1,T2,R1
3	Routh's criterion and Hurwithz criterion.	T1,T3,R1
4	Root Locus: Basic properties of root locus.	T1,T3,R1
5	Construction of root locus.	T1,T2,R1
6	Angle and magnitude condition for stable system.	T1,T3,R1
8	Rubrics	

Question Bank

Unit No.-III

0.1 Explain the concept of absolute, relative and marginal stability. [5]

Q2 For characteristic equation of feedback control system $S^4 + 25S^3 + 15S^2 + 20S + K = 0$ determine the range of K for stability by Routh - Harwitz Criteria. Determine the value of K so that system is marginally stable. Also find the frequency of sustained oscillations. [5]

Q. 3 Obtain Root locus for unity feedback system with open loop transfer function $G(s) = \frac{k}{s(s^2+6s+25)}$ [5]

Q4 A unity feedback system has

G(S) = K / S (S + 10) (S2 + 4S + 5).

Determine range of K for closed loop system to be stable.

Q5 Explain Routh Huruietz Stability Criterion.

Q6 Apply Routh Huruietz Criterion to check the stability of system whose characteristic equation is

s3+2.5 s2+20s+10k=0. Find the range of k for which system is absolutely stable.

Q7 Explain how to find the following terms during sketching of root locus

i) Breakaway points

ii) Asymptotes and centroid

iii) Angle of arrival

iv) Angle of departure

Q8 Sketch Root Locus for

$G(s) = \frac{k}{s(s^2+6s+12)}$ with H(s)=1

Unit No.-V: Frequency domain analysis.-II

Objectives: -

- To analyze behavior of system in frequency domain.

Outcomes: -

- Student can implement the stability analysis in frequency domain using Bode plot**.**

Lecture No.	Details of the Topic to be covered	References
1	Introduction to Bode plot,	T1,T2,R1
2	Asymptotic approximation: sketching of Bode plot,	T1,T2,R1
3	Stability analysis using Bode plot.	T1,T2,R1
8	Ruberics	

Question Bank:

Unit No.-IV & V

Q1 A unity feedback control system has $G(s)=\frac{40}{s(s+2)(s+5)}$ Draw Bode plot. Find GM &PM. [5]

.

Q2 State advantages and disadvantages of frequency & time domain analysis. [5]

Q3 Explain Nyquist stability criterion based on mapping theorem. [5]

Q4 Draw the bode plot for the system having unity feedback whose open loop transfer function is $G(s) = \frac{10}{s(1+0.1s)(1+0.04s)}$ [5]

Also determine

i) W_{ge} ii) W_{pc}

iii) GM iv) PM and

v) Stability.

Q. 5 Sketch the polar plot for the system whose open loop transfer function $G(s)H(s)=\frac{7}{s(1+s)(1+0.5s)}$ Comment on stability. [5]

Sketch the Nyquist plot and determine stability for $G(s)H(s)=\frac{1}{(1+s)(1+2s)}$.

Unit No.-VI:

PID controllers

Objectives: -

- To design controller to meet desired specifications.

Outcomes: -

- Student will be able to analyse and apply various methodology of feedback control system and evaluate the behaviour of system by frequency domain analysis.
- Student can construct, design and validate feedback controller to achieve desired performance specification.

Lecture No.	Details of the Topic to be covered	References
1	Basic concept of PID controller	T1,T3,R1
2	Design specifications in time domain	T1,T3,R1
3	Design specifications in frequency domain	T1,T3,R1
4	Time design of P,PI, PID controllers.	T1,T3,R1
5	Frequency domain design of P,PI,PID controllers	T1,T3,R1
6	Tuning of PID controllers	T1,T3,R1
7	Zigler-Nichol Method.	T1,T3,R1
8	Rubrics	

Question Bank: Theory

Unit No.-V

0.1	Explain Zigler-Nichol Method of tuning.	[6]
Q2	Time Design of P,PI,PID controllers.	[4]
Q3	Write short note P+I control system.	[6]
Q4	Explain PD control mode, stating its characteristics.	[6]
Q5	Write short note on Design of P,PI,PID controllers	[6]
Q6	State controller equations for the P, P + I, P + D and PID control actions.	[6]

Practical Assessment

List of Experiments

Sr.No.	Name of the Practical
1	Experimental study of time response characteristics of R-L-C second order system: Validation using simulation.
2	Experimental frequency response of Lag and Lead compensator.
3	Stability analysis using a) Bode plot b) Root locus c) Nyquist plot using software.
4	Effect of addition of pole-zero on root locus of second order system
5	PID control of level/Pressure/Temperature control system.
6	Transfer function of any physical systems (AC Servomotor/ Two Tank System/ Temperature control/ Level control)
7	Study of Synchro transmitter receiver.
8	Time response of second order system effect of P,PI, PID on it.

Elective-II: Energy Management (303151)

Name of Subject: Elective-II Energy Management

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	3	1	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	---	100	3

Prerequisite:

Various electrical equipment and specifications, Construction and operation of different equipment/process like HVAC, Pumps, Compressors etc.

Course Objectives:

The course aims to:-

1. Understand importance of energy Conservation and energy security and impact of energy use on environment.
2. Follow format of energy management, energy policy.
3. Understand demand side management tools and impact of tariff on demand management.
4. Importance of Data Analytics in Energy audit and audit process.
5. Calculate energy consumption and saving options with economic feasibility.
6. Use of appropriate energy conservation measure in field applications or industry.

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

CO1 Describe BEE Energy policies, Energy ACT.

CO2 List and apply demand side management measures for managing utility systems.

CO3 Explore and use simple data analytic tools.

CO4 Use various energy measurement and audit instruments.

CO5 Evaluate economic feasibility of energy conservation projects.

CO6 Identify appropriate energy conservations methods for electric and thermal utilities.

Unit 01 **Energy Scenario** **06 hrs**

Classification of Energy resources, Commercial and noncommercial sources, primary and secondary sources, commercial energy production, final energy consumption. Energy needs of growing economy, short terms and long terms policies, energy sector reforms, energy security, importance of energy conservation, energy and environmental impacts, introduction to CDM, UNFCCC, Paris treety, emission check standard, salient features of Energy Conservation Act 2001 and Electricity Act 2003. Latest amendments in Electricity Act. Indian and Global energy scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC).

Unit 02 Energy Management 06 hrs

Definition and Objective of Energy Management, Principles of Energy management, Energy Management Strategy, Energy Manager Skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup and energy management. Responsibilities and duties of energy manager under the latest Act. Energy Efficiency Programs. Energy monitoring systems.

Unit 03 Demand Management 06 hrs

Supply side management (SSM), Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and barriers, implementation of DSM. Use of demand side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control. Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.) Introduction to ISO 50001- Energy Management.

Unit 04 Energy Audit 06 hrs

Definition, need of energy audits, types of audit, procedures to follow, data and information analysis, Introduction to Data Analytics, data quality processing, clustering techniques, pattern mining, regression and classification. Relevance of Data Analytics in Audit, energy audit instrumentation,

energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy

performance of an industry. Energy Audit reporting format – Executive Summary , Detailing of report.

Unit 05 Financial Analysis 06 hrs

Financial appraisals; criteria, simple payback period, return on investment, net present value method, time value of money, break even analysis, sensitivity analysis and numerical based on it, cost of energy, cost of generation Energy Audits case studies – Sugar Industry, Steel Industry, Paper and Pulp industry.

Unit 06 Energy Conservation 06 hrs

a) Motive power (motor and drive system). b) Illumination c) Heating systems (boiler and steam systems) d) Ventilation(Fan, Blower and Compressors) and Air Conditioning systems e) Pumping System f) Cogeneration and waste heat recovery systems g) Utility industries (T and D Sector) and Performance Assessments

Test Books:

[T1] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 1, General Aspects (available on line)

[T2] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 2 – Thermal Utilities (available on line)

[T3] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 3- Electrical Utilities (available on line)

[T4] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 4 (available on line)

Reference Books:

[R1] Success stories of Energy Conservation by BEE (www. Bee-india.org)

[R2] Utilization of electrical energy by S.C. Tripathi, Tata McGraw Hill.

[R3] Energy Management by W.R. Murphy and Mackay, B.S. Publication.

[R4] Generation and utilization of Electrical Energy by B.R. Gupta, S. Chand Publication

[R5] Energy Auditing made simple by Balasubramanian, Bala Consultancy Services.

[R6] A General Introduction to Data Analytics by Andre Carvalho and Tomáš Horváth Wiley Inc First Edition 2019.

Online Resources:

[O1] www.energymanaertraining.com

[O2] www.em-ea.org

[O3] www.bee-india.org

[O4] https://www.iso.org/iso-50001-energy-management.html

Unit	Text Books	Reference Books
Unit 1	T1	O1, O2
Unit 2	T1	O1, O2
Unit 3	T1	R4, O4
Unit 4	T1	R4, R5 and O1 and O2, R6
Unit 5	T1 and T4	R1, R2, R3, R5 O1 and O2
Unit 6	T2, T3 and T4	R1, R5 and O1 and O2

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

Sr. No.	Unit	Broad Topic to be covered	Books Referred	Total Lectures Planned
1	I	Energy Scenario	T1	06
2	II	Energy Management	T1,	06
3	III	Demand Management	T1, R4	06
4	IV	Energy Audit	T1,R5	06
5	V	Financial Analysis	T1,R4,R5,R6	06
6	VI	Energy Conservation	T1,T4,R1,R2,R3,R5	06

PROGRESSIVE EDUCATION SOCIETY'S

MODERN COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL

Unit wise Lecture Plan

Unit : 01 Energy Scenario

Pre-requisites:-

- Basic concepts of Energy scenario in India and Energy management.

Objective :-

- Understand importance of energy Conservation and energy security and impact of energy use on environment

Outcome :

- Describe BEE Energy policies, Energy ACT.

Lect. No	Details of the Topic to be covered	References	Mode of Delivery
1	Classification of Energy resources, Commercial and noncommercial sources, primary and secondary sources, commercial energy production,	T1, R1	PPT
2	final energy consumption. Energy needs of growing economy, short terms and long terms policies,	T1, R1	PPT
3	energy sector reforms, energy security, importance of energy conservation,	T1, R1	PPT
4	energy and environmental impacts, introduction to CDM, UNFCCC, Paris treety, emission check standard	T1, R1	PPT
5	salient features of Energy Conservation Act 2001 and Electricity Act 2003. Latest amendments in Electricity Act.	T1, R1	PPT
6	Indian and Global energy scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC).	T1, R1	PPT/Video

Question Bank: Theory

Unit I

1. List at least five States where coal deposits are concentrated in India.
2. What do you think of strategies required for long-term management of energy in India?
3. Discuss the subsidies and cross subsidies in oil sector in India.
4. What are the implications of Global warming?
5. Describe the Greenhouse effect.
6. Differentiate between energy conservation and energy efficiency.
7. Why energy conservation is important in the prevailing energy scenario?
8. Name five designated consumers under the energy conservation act.
9. Write in few words about the various reforms in the energy sector.
10. What is the significance of Energy Conservation
11. Decribe Salient features of Electricity Act 2003
12. List out Salient features of Energy Conservation Act-2001
13. Explain Short term and Long term policies in India with respective energy resources.

Unit : 02 Energy Management

Pre-requisites:-

- Basic concepts of Energy scenario in India and Energy management.

Objective :-

- Follow format of energy management, energy policy.

Outcome :

- Understand Energy Manager Role & Responsibilities.

Lect . No	Details of the Topic to be covered	References	Mode of Delivery
1	Definition and Objective of Energy Management, Principles of Energy management, Energy Management Strategy,	T1	PPT
2	Energy Manager Skills, key elements in energy management,	T1	PPT
3	force field analysis, energy policy, format and statement of energy policy,	T1	PPT
4	Organization setup and energy management.	T1	PPT
5	Responsibilities and duties of energy manager under the latest Act	T1	PPT
6	Energy Efficiency Programs. Energy monitoring systems.	T1	PPT

Question Bank: Unit II

1. Explain the concept of energy management and its objectives.
2. Explain Energy Management Strategy.
3. Explain in detail Force Field Analysis.
4. What are the Responsibilities of Energy Manager under ECA 2001?
5. What are the key elements of Energy Management?

Unit No.-III: Demand Management

Pre-requisites:-

- Basic concepts of Supply Side Management and Demand Side Management

Objectives:-

- Understand demand side management tools and impact of tariff on demand management

Outcomes:-

- Students will be able to List and apply demand side management measures for managing utility systems.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Concepts of Supply side management (SSM)& Demand Side Management(DSM) Generation system up gradation,	T1,R4	PPT
2	Constraints on SSM. Demand side management (DSM), advantages and barriers, implementation of DSM.	T1,R4	PPT
3	Use of demand side management in agricultural, domestic and commercial consumers.	T1,R4	PPT
4	Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control.	T1,R4	PPT
5	Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.)	T1,R4	PPT
6	Introduction to Net Metering.	T1,R4	PPT

Question Bank: Unit No.-III

1. What is Supply side Management SSM)?
2. What are various methods involved in SSM?
3. Explain the concept of Demand Side Management (DSM).
4. Explain DSM in agricultural, domestic and commercial consumers.
5. Explain the role of renewable energy sources in energy management.
6. Explain TOD.

Unit No.-IV: Energy Audit

Pre-requisites:-

- Concepts of Electricity Act- 2003

Objectives:-

- Learn various tools of energy audit and management

Outcomes: -

After successfully completion of this unit students will be able to:

- Understand the use of various energy measurement and audit instruments
- Execute preliminary energy audit of various sectors.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Definition, need of energy audits, types of audit, procedures to follow.	T1 , R4, R5 ,R6	PPT
2	Data and information analysis, energy audit instrumentation.	T1 , R4, R5 ,R6	PPT
3	Energy consumption – production relationship, pie charts. Sankey diagram,	T1 , R4, R5 ,R6	PPT/Chalk and talk
4	Cusum technique, least square method and numerical based on it..	T1 , R4, R5 ,R6	PPT/Chalk and talk
5	Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options	T1 , R4, R5 ,R6	PPT
6	Bench- marking energy performance of an industry. Report formats	T1 , R4, R5 ,R6	PPT

Question Bank: Unit No.-IV

1. Define energy audit and its need.
2. What are different types of energy audit?
3. What are various instruments used in energy audit?
4. Explain in detail Sankey Diagram.
5. Explain in detail Cusum Technique.
6. What is the typical format of Energy Audit Report?

Unit No.-V: Financial Analysis

Pre-requisites:-

- Concepts of Electricity Act- 2003

Objectives:-

- Learn various tools of energy audit and management

Outcomes: -

- Students will be able to: Calculate energy consumption and saving options with economic feasibility.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Financial appraisals; criteria, simple payback period, return on investment,	T1 ,T4 ,R1, R2, R3, R5	PPT /Chalk and talk
2	net present value method, time value of money, break even analysis,	T1 ,T4 ,R1, R2, R3, R5	PPT / Chalk and talk
3	sensitivity analysis and numerical based on it, cost of energy,	T1 ,T4 ,R1, R2, R3, R5	PPT /Chalk and talk
4	cost of generation Energy Audits case studies – Sugar Industry	T1 ,T4 ,R1, R2, R3, R5	Chalk and talk/ PPT
5	Energy Audits case studies – Steel Industry,	T1 ,T4 ,R1, R2, R3, R5	PPT
6	Energy Audits case studies – Paper and Pulp industry.	T1 ,T4 ,R1, R2, R3, R5	PPT

Question Bank: Unit No.-V

1. Describe different costing techniques used for energy management?
2. Explain cash flow diagrams and activity chart.
3. Explain in detail net present value method.
4. Explain in detail Break even analysis
5. Explain sensitivity analysis
6. Explain Following financial terms: Simple payback period, Time value of money, Net present value, Internal rate of return
7. Explain process of cost optimization.
8. Explain various financial appraisal methods used in economic analysis of energy conservation project.

Unit No.-VI: Energy Conservation

Pre-requisites:-

- Construction and operation of different equipment/process like HVAC, Pumps, Compressors etc.

Objectives:-

- Use of appropriate energy conservation measure in field applications or industry.

Outcomes: -

- Students will be able to: Identify appropriate energy conservations methods for electric and thermal utilities.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	a) Motive power (motor and drive system).	T2, T3, T4,R1, R5	PPT
2	b) Illumination	T2, T3, T4,R1, R5	PPT
3	c) Heating systems (boiler and steam systems)	T2, T3, T4,R1, R5	PPT
4	d) Ventilation(Fan, Blower and Compressors) and Air Conditioning systems	T2, T3, T4,R1, R5	PPT
5	e) Pumping System	T2, T3, T4,R1, R5	PPT
6	f) Cogeneration and waste heat recovery systems g) Utility industries (T and D Sector) and Performance Assessments.	T2, T3, T4,R1, R5	PPT

Question Bank: Unit No.-VI

Q.Explain energy conservation in:

a) Motive power (motor and drive system).

b) Illumination

c) Heating systems (boiler and steam systems)

d) Ventilation(Fan, Blower, Compressors) and Air Conditioning systems

e) Pumping System

f) Cogeneration and waste heat recovery systems

g) Utility industries (T and D Sector)

h) Diesel generators.

Elective-II: Electrical Mobility

(303151B)

Name of the Subject –Electric Mobility

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

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	-	100	03

Syllabus:

Unit 01 Introduction to Hybrid and Electric vehicles 06 hrs

Need and importance of Electric Vehicle and Hybrid Electric Vehicles, Environmental importance of Hybrid and Electric vehicles. Hybrid Electric vehicles: Concept and architecture of HEV drive train (Series, parallel and series-parallel). Micro Hybrid, Mild Hybrid, Full Hybrid, Plug-in Hybrid, Electric vehicles: Components, configuration, performance, tractive effort, Advantages and challenges in EV.

Unit 02 Energy Storage Systems 06 hrs

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery specifications, Battery based energy storage and its analysis, Classification of lithium-ion batteries, Aluminum Air and Aluminum ion battery. Fuel Cell based energy storage, Super Capacitor based energy storage, Hybridization of Ultra capacitor and Battery. Selection methodology for the energy storage.

Unit 03 Battery Charging and Management Systems 06 hrs

Introduction: Different charging algorithms and Charging method, Cell Balancing methods. Battery Management System: Functions of BMS, Block diagram of BMS. SoC Estimation methods, Thermal Management of Battery.

Unit 04 Hybrid Power Train and mode of operation 06 hrs

Control Strategies and Design of the Major Components: Series and Parallel Hybrid Electric

Drive Train. Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Regenerative braking

Unit 05 Drives and Charging Infrastructure

Selection of drives for Electric vehicle: PMSM drive and BLDC drive, Sizing of motor, Charging Levels: 01,02 and 03, Charging Standards: CCS, CHAdeMO, SAE J1772, IEC 60309, Bharat DC 001, Bharat AC 001, Electric Vehicle Supply Equipment (EVSE).

Unit 06 Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid

Vehicle to Home: Introduction, applications, V2H with demand response, Case Study of V2H. Vehicle to Grid: Introduction of V2G, V2G infrastructure in the smart grid, Role of aggregator for V2G, Case study of V2G, Vehicle to Vehicle: Introduction of V2V, Concept & structure.

Test Books:

[T1] "Electrical Vehicle", James Larminie and John Lowry, John Wiley & Sons, 2012.
Savitribai Phule Pune University
TE Electrical (2019 course) 39
[T2] "Electric and Hybrid-Electric Vehicles", Ronald K. Jurgen, SAE International Publisher.
[T3] "Energy Systems for Electric and Hybrid Vehicles", K T Chau, The institution of Engineering and Technology Publication
[T4] "Batteries for Electric Vehicles", D.A.J Rand, R Woods & R M Dell, Research studies press Ltd, New York, John Willey & Sons
[T5] Electric & Hybrid Vehicles-Design Fundamentals, CRC press

Reference Books:

[R1] "Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamental, Theory and design", Mehrdad Ehsani, Yimin Gao and Ali Emadi. CRC Press, 2009.
[R2] "Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", Junwei Lu & Jahangir Hossain et al (eds), IET Digital Library.
[R3] "Automobile Electrical and Electronic systems", Tom Denton, SAE International publications.
[R4] "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", C. Mi, M. A. Masrur and D. W. Gao, John Wiley & Sons, 2011.

[R5] The Electric Vehicle Conversion handbook –Mark Warner, HP Books, 2011. Online

Resources:

[O1] https://www.theiet.org/resources/books/transport/vehicle2grid.cfm?

[O2] https://www.sae.org/publications/books/content/pt-143.set/

[O3] https://nptel.ac.in/courses/108103009/

Course Objectives:

This course aims to

1. To make students understand the need & importance of Electric & Hybrid Electric vehicles.

2. To differentiate and analyze the various energy storage devices.

3. To impart the knowledge about architecture and performance of Electric and Hybrid Vehicles

4. To classify the different drives and controls used in electric vehicles.

Course Outcomes:

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

CO1 Analyze the concepts of Hybrid and Electric vehicles.

CO2 Describe the different types of energy storage systems

CO3 Comprehend the knowledge of the battery charging and management systems.

CO4 Classify the different mode of operation for hybrid vehicle.

CO5 Apply the different Charging standards used for electric vehicles.

CO6 Differentiate between Vehicle to home & Vehicle to grid concepts.

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	Introduction to Hybrid and Electric vehicles	06
2	II	Energy Storage Systems	06
3	III	Battery Charging and Management Systems	06
4	IV	Hybrid Power Train and mode of operation	06
5	V	Drives and Charging Infrastructure	06
6	VI	Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid	06

Unit wise Lecture Plan

Unit No.-I: Introduction to Hybrid and Electric vehicles

Prerequisite:

Basic concept of hybrid electric vehicle

Objective:

To Analyse the concepts of Hybrid and Electric vehicles

Outcome:

Student will able to understand the concepts of Hybrid and Electric vehicles.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Need and importance of Electric Vehicle and Hybrid Electric Vehicles,	T2,T5,R1	PPT
2	Environmental importance of Hybrid and Electric vehicles.	T2,T5,R1	PPT
3	Hybrid Electric vehicles: Concept and architecture of HEV drive train (Series, parallel)	T2,T5,R1	Green board
4	Hybrid Electric vehicles: Concept and architecture of HEV drive train (Series-parallel).	T2,T5,R1	PPT
5	Micro Hybrid, Mild Hybrid, Full Hybrid, Plug-in Hybrid	T2,T5,R1	PPT
6	Electric vehicles: Components, configuration, performance, tractive effort, Advantages and challenges in EV	T2,T5,R1	Green Board

Question Bank:

Unit 1: Introduction to Hybrid and Electric vehicles

1. Write a short note on History of Electric Vehicle.
2. Write a short note on Hybrid Electric Vehicle.
3. Why EVs Emerged and Failed in the 1990s?
4. Write a short note on Fuel cell Vehicle.
5. What are the Social and environmental importance of Hybrid and Electric vehicles?
6. What is the Impact of modern drivetrains on energy supplies?
7. Define transmission and describe basic types of transmission for automobile applications.
8. What do you mean by Power Plant Characteristics? What is its importance for on road performance of vehicles?
9. Write a short note on Manual Gear Transmission.
10. Write a short note on Hydrodynamic Transmission.
11. Write a short note on Continuously Variable Transmission.
12. Describe the Vehicle performance.
13. Mention the techniques by which vehicle fuel economy can be improved.

Unit No.-II: Energy Storage Systems

Pre-requisites:-

- Basic working principle of batteries

Objectives:-

- To understand Energy storage system

Outcomes: -

- After successfully completing this unit students will be able to understand energy storage system.

Lecture No.	Details of the Topic to be covered	References	Mode of delivery
1	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles,	T1,T2,T4,R1,R4	Green board
2	Classification of lithium-ion batteries.	T1,T2,T4,R1,R4	PPT
3	Aluminum Air and Aluminum ion battery.	T1,T2,T4,R1,R4	PPT
4	Fuel Cell based energy storage, Super Capacitor based energy storage.	T1,T2,T4,R1,R4	PPT
5	Hybridization of Ultra capacitor and Battery. Selection methodology for the energy storage.	T1,T2,T4,R1,R4	Green board
6	Battery specifications, Battery based energy storage and its analysis.	T1,T2,T4,R1,R4	PPT

Question Bank: Theory

1. Explain need of energy storage in HV and EHV.
2. Write a note on Hybridization of energy sources for EV and EHV.
3. Compare Battery based and Fuel cell-based energy storage system for EV and EHV.
4. Write a selection criterion for energy storage technology.
5. State different types of energy storage system and explain ultra-capacitor based or Flywheel based energy storage system in detail with performance parameters.
6. Explain Different types of Batteries & their operation and performance.
7. Explain about energy storage requirements in Hybrid and Electric vehicles.
8. Explain battery-based energy storage and its analysis w.r.t application in EV and EHV.
9. Explain Fuel cell-based energy storage and its analysis w.r.t application in EV and EHV.
10. Explain Ultra capacitor-based energy storage and its analysis w.r.t application in EV and EHV.
11. Explain flywheel-based energy storage and its analysis w.r.t application in EV and EHV.
12. Write the importance of Hybridization of energy sources for Hybrid and Electric vehicle.
13. Write a short note on Hybridization of energy storage in EVs.
14. Explain the Hybridization of drive trains in HEVs.

Unit No.-III: Battery Charging and Management Systems

Pre-requisites:-Basic working Battery Charging and Management Systems

Objectives :-

- To understand Different charging methods.
- To study Battery management system.

Outcomes: -

- After successfully completing this unit students will be able to understand Battery Charging and Management Systems

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction: Different Charging algorithms and	T3,T4,T5,R1,R4,R5	PPT
2	Charging method,	T3,T4,T5,R1,R4,R5	PPT
3	Cell Balancing methods.	T3,T4,T5,R1,R4,R5	PPT
4	Battery Management System: Functions of BMS	T3,T4,T5,R1,R4,R5	PPT
5	Block diagram of BMS.	T3,T4,T5,R1,R4,R5	PPT
6	SoC Estimation methods, Thermal Management of Battery.	T3,T4,T5,R1,R4,R5	PPT

Question Bank: Theory

1. Write a short note on Battery charging system.
2. Write a short note on Battery Management system
3. Write a short note on charging algorithm.
4. Explain Following Charging algorithm
   a) Constant Current (CC) charging for NiCd/NiMH batteries
   b) Constant Voltage (CV) charging

c) CC/CV charging

d) MSCC charging.

e) TSCC/CV charging

5. Describe charging termination techniques.

6. Describe balancing method for battery pack charging.

7. Describe Battery sorting balancing method for battery pack charging.

8. Describe active balancing method for battery pack charging.

9. Describe passive balancing method for battery pack charging.

10. Write a short note on Battery Management system.

11. Describe component and blocks of Battery management system representation.

12. What do you mean by SoC and SoH?

13. Compare methods of estimation of SoC.

14. List out battery balancing methods and describe any one in detail.

15. Write a short note on Thermal monitoring of Battery unit.

16. Describe Basic terms for charging performance evaluation and characterization.

a) SOH

b) C rate

c) Cut off current.

d) Nominal ampere hour Capacity

e) energy efficiency

Unit No.-IV: Hybrid Power Train and mode of operation

Pre-requisites:-

- Basic of Hybrid Power Train and mode of operation

Objectives:-

- To understand Control Strategies and Design of the Major Components of Series Hybrid Electric Drive Train
- To learn Control Strategies and Design of the Major Components of Parallel Hybrid Electric Drive Train
- To study Braking Power and Energy on Front and Rear Wheels, Brake System of HEVs.

Outcomes:- Student will be able to Classify the different mode of operation for hybrid vehicle

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Control Strategies and Design of the Major Components: Series Hybrid Electric Drive Train.	T1,T3,T4,T5,R4	PPT
2	Control Strategies and Design of the Major Components: Parallel Hybrid Electric Drive Train.	T1,T3,T4,T5,R4	PPT
3	Energy Consumption in Braking,	T1,T3,T4,T5,R4	PPT
4	Braking Power and Energy on Front and Rear Wheels, Brake System of EVs	T1,T3,T4,T5,R4	PPT
5	Braking Power and Energy on Front and Rear Wheels, Brake System of HEVs	T1,T3,T4,T5,R4	PPT
6	Regenerative braking	T1,T3,T4,T5,R4	PPT

Question Bank: Theory

1. Explain the components of Electrical Vehicles.
2. Describe in brief configuration used for electrical vehicles.
3. Write a short note on performance of electrical vehicles.
4. Write a short note on concept of Hybrid Electric Vehicles.
5. Write a short note on architecture of HEV drive train.
6. Explain in detail series hybrid drive train configuration.
7. Explain in detail Parallel hybrid drive train configuration.
8. Explain in detail series-parallel hybrid drive train configuration.
9. Write a short note about Energy consumption of EV and HEV.
10. What are the advantages and challenges in electrical vehicle design?
11. Write a short note on tractive efforts in normal driving.

Unit No.-V Drives and Charging Infrastructure

Pre-requisites:-

- Electrical Drives and control

Objectives:-

- To study various drives and charging structure

Outcomes: -

- After successfully completing this unit students will be able to understand Drives and Charging Infrastructure

Lecture No.	Details of the Topic to be covered	References	Mode of delivery
1	Selection of drives for Electric vehicle: PMSM drive.	T1,T3,T4,T5,R1	PPT
2	Selection of drives for Electric vehicle: BLDC drive.	T1,T3,T4,T5,R1	PPT
3	Sizing of motor, Charging Levels: 01, 02 and 03.	T1,T3,T4,T5,R1	PPT
4	Charging Standards: CCS, CHAdeMO,	T1,T3,T4,T5,R1	PPT
5	Charging Standards: SAE J1772, IEC 60309	T1,T3,T4,T5,R1	PPT
6	Charging Standards: Bharat DC 001, Bharat AC 001, and Electric Vehicle Supply Equipment (EVSE).	T1,T3,T4,T5,R1	PPT

Question Bank: Theory

1. Describe the Brushless dc Motor drives used for EV and HEV.
2. Describe the Switched reluctance Motor drives used for EV and HEV.
3. Compare performance characteristics used for EV and HEV.
4. Write a short note on instrumentation and control system related to Hybrid and Electric vehicles.
5. Describe the speed control for EV and HEV.
6. Describe the motion control for EV and HEV.
7. Describe the breaking mechanism for EV and HEV.
8. Write a short note on Electrical steering and mention advantages of electrical steering.
9. Explain acceleration characteristics of EV and HEV.
10. Write a short note on Vehicle tracking through GPS.
11. Write a short note on over speed indicating systems.
12. Write a short note on Auto-parking systems.

Unit No.-VI: Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid

Pre-requisites:-

- Basic of Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid

Objectives:-

- To understand applications of V2H with demand response and Case Study of V2H.
- To learn Introduction of V2G, V2G infrastructure in the smart grid and Case study of V2G
- To study Introduction of V2V, Concept & structure.

Outcomes:-

- Students will be able understand differentiate between Vehicle to home & Vehicle to grid concepts..
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Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Vehicle to Home: Introduction, applications,	T1,T2,T3,T5,R2,R3	PPT
2	V2H with demand response, Case Study of V2H	T1,T2,T3,T5,R2,R3	PPT
3	V2G infrastructure in the smart grid,	T1,T2,T3,T5,R2,R3	PPT
4	Vehicle to Grid: Introduction of V2G	T1,T2,T3,T5,R2,R3	PPT
5	Role of aggregator for V2G, Case study of V2G.	T1,T2,T3,T5,R2,R3	PPT
6	Vehicle to Vehicle: Introduction of V2V, Concept & structure.	T1,T2,T3,T5,R2,R3	PPT

Question Bank: Theory

1. Describe Vehicle to Home (V2H) concept.
2. Describe following in Vehicle to Home(V2H)
   a) PHEV control Strategies to V2H applications
   b) V2H with demand response.
3. Describe the concept of Vehicle to Vehicle(V2V)
4. Write a short not on Concept and structure of EV aggregator and its control methods.
5. Explain control method for EV aggregator for dispatching a fleet of EV.
6. Describe the concept of Vehicle to grid (V2G) and its planning of V2G infrastructure in the smart grid.
7. Explain ancillary services provided by V2G.
8. Explain the concept of cost emission optimization