GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Electrical Engineering

Subject Code: BE05009021

Subject Name: Power Systems-II

WEF From Academic Year	2024-25
Semester	5
Category of the Course	Professional Core Course

Prerequisite	Basic knowledge of Electrical Engineering and Electrical Power Systems
Rationale	This course focuses on modelling and performance of transmission lines and analysis of various types of balanced and unbalanced faults in the power system. Further, it also covers the concept of corona phenomenon in transmission lines. Additionally, the course also addresses the important aspects related to over-voltages and transients in power systems.

Course Outcomes:

After the completion of course, students will be able to

No	Course Outcomes	% Weightage
1	Develop per-unit representation and impedance diagrams of power system components including transformers, synchronous machines, and loads.	10
2	Analyze performance of short, medium, and long transmission lines, Power flows, Ferranti effect, and corona phenomenon.	30
3	Perform symmetrical fault analysis and determine short-circuit currents and fault level at various locations in a transmission line.	15
4	Construct sequence networks using symmetrical components and analyze various types of unsymmetrical faults (SLG, LL, LLG, open conductor faults) on transmission lines	25
5	Analyse the effect of over-voltages due to lightning strokes and travelling waves in power systems.	20

Teaching and Examination Scheme

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial/Practical			
L	T	P	PBL	TH		ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	(200)

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

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*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Sr. No	Course Content	No. of hours
1	**Representation of Power System Components:** One line impedance diagram, Per unit system, Per unit representation of transformer, Per unit impedance diagram of power system, and impedance diagram, Representation of loads. Examples	4
2	**Transmission Line Modeling and Performance:** Introduction, Short transmission line, Medium transmission line, Long transmission line – Rigorous solution, Evaluation of ABCD constants, Interpretation of long line equations, Ferranti effect, Power flow through a transmission line, Examples	12
3	**Corona:** Critical Disruptive Voltage, Corona Loss, Line Design based on Corona, Disadvantages of Corona, Radio Interference, Inductive interference between Power and Communication lines, Examples.	4
4	**Symmetrical Fault Analysis:** Introduction, Transient on a transmission line, Short circuit of a synchronous machine on no load, Short circuit of a loaded synchronous machine, Selection of circuit breakers, Examples	5
5	**Symmetrical Components:** Symmetrical component transformation, Phase shift in star-delta transformers, Sequence impedances of transmission lines, Sequence - impedances and networks of synchronous machines, Sequence impedances and networks of transformers, Sequence impedance of transmission lines, Construction of sequence networks of a power system, Examples.	6
6	**Unsymmetrical Fault Analysis:** Introduction, Symmetrical component analysis of unsymmetrical faults, Single line to ground fault, Line to line fault, Double line to ground fault, Examples	5
7	**Transients in Power System** Travelling waves on open end line, Short circuited line, Line terminated through a resistance, Line connected to a cable, Reflection and refraction at a T-junction, Line terminated through a capacitance, capacitor connection at T, Attenuation of travelling waves, Capacitance switching, Examples	6
8	**Over-voltages in Power Systems:** Causes of over-voltages, Internal causes of over-voltages, Mechanism of lightning discharge, Types of lightning strokes, Harmful effects of lightning.	3

The syllabus of Electrical Power Systems-II directly contributes to Sustainable Development Goals No. 9, 11 and 12

SDG 9	**Industry, Innovation and Infrastructure** Students analyze the performance of short, medium, and long transmission lines. This directly contributes to design and optimization of electrical infrastructure, a backbone of industrial growth. Study of symmetrical and unsymmetrical faults, sequence networks, and short-circuit calculations enables engineers to design robust and fault-tolerant power systems, essential for industrial reliability. Understanding lightning, travelling waves, and switching transients ensures infrastructure protection and longevity, reducing system failures.
SDG 11	**Sustainable Cities and Communities** Fault studies ensure quick fault detection and system stability. It minimizes outages which is critical for urban infrastructure (transport, hospitals, smart cities). Lightning protection and surge analysis, protects urban electrical networks and buildings, enhancing safety. Addresses radio interference and power losses. Important for urban communication systems and environmental comfort.
SDG 12	**Responsible Consumption and Production** Transmission line performance analysis helps reduce energy losses during transmission, ensuring efficient resource utilization. Calculation of corona loss and its dependence on system parameters enables design improvements to minimize energy wastage. Transient & Over-voltage Management prevents equipment damage which in turn reduces material waste and replacement needs.

Applicable BIS standards

- BIS 5613
  Code of Practice for Design, Installation and Maintenance of Overhead Power Lines
- BIS 13234
  Guide for short-circuit calculation in three-phase
- BIS 2309
  Protection of buildings and allied structures against lightning

Suggested Specification table with marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	25	25	20	0

Legends:R:Remembrance;U:Understanding,A:Application,N:Analyze,E:Evaluate C: Create(RevisedBloom's Taxonomy)

Reference Books:

1. Modern Power system Analysis: I.J.Nagrath, D.P.Kothari, McGraw Hill Education
2. Electrical Power systems: C.L. Wadhwa,New Age International Publishers
3. Power System Analysis: Hadi Saadat, Mc Graw Hill Education India Pvt Ltd.
4. Power System Analysis and Design: J. Duncan Glover, Thomas J. Overbye, Mulukutla S. Sarma, Cengage Learning India Pvt. Ltd.
5. Power System Analysis: John J. Grainger, William D. Stevenson Jr., Mc Graw Hill Education

Suggested list of practicals:

1. To write computer program and obtain voltage regulation and efficiency of short transmission line for different specified set of sending and receiving end quantities
2. To write a computer program and obtain voltage regulation and efficiency of a medium transmission line (using πmodel& T model) for different specified set of sending and receiving end quantities
3. To write computer program to calculate voltage regulation and efficiency of a long transmission line using distributed capacitance model for different specified set of sending and receiving end quantities
4. To analyze the consequence of ferranti effect on the performance of transmission line.
5. To evaluate performance of transmission line using sending end power circle diagram and receiving end power circle diagram
6. To write a computer program to analyse the effect of variation of frequency on corona
7. To simulate transients in series R-L circuit with change in DC offset current for application of excitation at different instant
8. To develop program to transform three phase unbalanced phasor into its symmetrical components and vice versa.
9. To develop a computer program for verifying power invariance in symmetrical components.
10. To develop a computer program for calculating fault currents for different types of unsymmetrical faults.

11. To obtain voltage profile and loadability curve for transmission line.
12. To compute shunt capacitor compensation and performance of loaded line.
13. To write a computer program for analysing/simulating traveling waves of a long transmission line.

1. **Suggested PBL activities**

Sr. No	PBL Category	Name of the activity	No of hours	Evaluation criteria
1	Complex Problem-Solving	Develop per-unit representation and impedance diagrams of any particular transmission line of Gujarat/India (preferable) **OR** Assume a 3-bus system with: • Generator • Transformer • Transmission line • Load Convert all quantities into per unit on common base. Draw per unit impedance diagram. Change MVA base and redraw p.u. diagram.	05	• Correct base selection, proper conversion to per unit. • Clean, correct per-unit impedance diagram. • Accurate calculations. • Understanding effect of base change.
2	Micro Project + Complex Problem-Solving	Select any transmission line of Gujarat/India and evaluate its performance for a particular load condition (preferable) **OR** Model 132 kV or 220 kV transmission line. Calculate: • ABCD constants • Sending end voltage/current • Voltage regulation • Efficiency Demonstrate Ferranti effect. Compare short vs medium vs long line model. Show analytical calculations and compare the results using MATLAB/Octave.	05	• Correct ABCD constants derivation. • Correct voltage regulation & efficiency. • Short vs Medium vs Long line comparison. • Conceptual clarity.
3	Case Study Analysis / Complex Problem-Solving	To analyse the case study of major short circuit of any transmission line of Gujarat/India (preferable) **OR** Consider a 2-bus or 3-bus system. Calculate: • 3-phase fault current • Single line to ground fault • Line-to-line fault • Double line to ground fault Construct sequence networks manually.	05	• Correct sequence network construction. • Correct calculation of fault currents. • Comparison & technical explanation. • Proper

		Compare magnitude of different fault currents. Comment on most severe fault and practical implications.		interpretation
4	Simulation-Based Learning + Micro Project	Analyse and comprehend lightning and travelling wave protection design of a transmission line of Gujarat/India (preferable) **OR** Simulate and understand reflection and refraction of travelling waves Simulate: • Open end line. • Short circuited line. • Line terminated through resistance. • Calculate reflection and refraction coefficients. • Study effect of surge impedance. • Write a MATLAB/Octave program	05	• Correct coefficient calculation. • Clear understanding of surge behaviour. • Practical implication discussion.
5	Mini Project + Complex problem solving	Select any 220 kV / 400 kV transmission line of Gujarat/India. (preferable) Assume: (if data is not available) • Conductor radius • Spacing between conductors • Air density factor Calculate: • Critical Disruptive Voltage • Visual Critical Voltage • Corona Power Loss (Peek's formula) Study effect of: • Frequency variation • Conductor spacing variation • Bundle conductor configuration **OR** Compare: • Single conductor vs bundled conductor system Calculate : • Critical Disruptive Voltage • Visual Critical Voltage • Corona Power Loss (Peek's formula) Evaluate reduction in corona loss. Recommend economical design improvement.	10	• Correct calculation of critical disruptive voltage. • Correct corona loss calculation. • Parametric study (spacing / frequency / bundling). • Interpretation of results. • Recommendation and report quality

Note:

- In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Electrical distribution systems incorporates;
  - Mini Project – 10 Marks
  - Micro Project and – 5 Marks

  These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

  - All the suggested activities should be related to the subject.
  - · Faculty can consider other subject based activities.
  - · The number of hours is suggestive. Faculty can sub-divide the number of hours based on the
  - activity. However, total number of hours is fixed.

· Rubrics for the evaluation can be prepared by the faculty.

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.

- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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