GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Electrical Engineering
Subject Code: BE03009031
Subject Name: Electrical Circuit Analysis

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Professional Core Course

Prerequisite:	Solution of simultaneous linear equations, Solution of linear constant coefficient differential equations, Basics of LaPlace transform
Rationale:	Electrical Circuit Analysis equips students with essential skills to analyze and solve complex electrical circuits and networks. The syllabus encompasses key topics such as network theorems, transient and steady-state responses, sinusoidal analysis, Laplace transforms, and two-port networks. These concepts enable students to understand, model, and optimize circuit performance, fostering problem-solving and analytical abilities. This course lays the groundwork for advanced studies and practical applications in electrical engineering, preparing students for challenges in power systems, electronics, and control systems.

Course Outcomes:

The students will be able to

Sr. No.	CO Statement	Marks % weightage
CO-1	Analyze electrical circuits with independent and dependent sources by nodal analysis and mesh analysis, and network theorems	25
CO-2	Assess the initial and final conditions of circuit elements, and evaluate the transient and steady-state responses of first-order RL, RC, and second-order RLC circuits	25
CO-3	Apply the concept of the complex exponential forcing function to determine the sinusoidal steady-state response of electrical circuits by transforming circuits into their phasor equivalent representations	10
CO-4	Apply Laplace transform methods to solve differential equations and analyze electrical circuits in the s-domain by developing s-domain equivalent circuits	25
CO-5	Analyze the network behavior using two-port parameters and evaluate the interrelationships between these parameters	15

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	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	15	30	30	120	04	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

Content:

Sr. No.	Content	Total Hrs.	% Weightage
1	**Network Theorems and Coupled circuits** Solution of circuits with independent sources using Node and Mesh analysis, Classification of dependent sources, Solution of circuits with dependent sources using Node and Mesh analysis, Concept of Super-node and Super- mesh in circuits with independent and dependent sources, Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem for circuits with independent and dependent sources, Concept of duality and dual networks, Mutually coupled circuits, Dot Convention in coupled circuits.	12	25
2	**Initial and Final Conditions** Initial and final conditions in elements, Concept of steady state and transient state response, The series RL circuit, Step response of RL circuit by solving differential equations, Features of RL circuit step response, Steady state response and forced response, Linearity and superposition in dynamic circuits, RC Circuit equations, Zero-Input response of RC circuit, Zero-State response of RC circuits for various inputs, The series RLC circuit zero-input response, Step response of series RLC circuit, Transient response of RLC circuit with sinusoidal excitation.	09	25
3	**Sinusoidal Steady State Analysis** The complex exponential forcing function, Sinusoidal steady state response using complex exponential ($e^{\pm j\omega}$), Concept of the phasor, Transforming a circuit in to phasor equivalent circuit, Sinusoidal steady state response from phasor equivalent circuit	05	10
4	**Electrical Circuit Analysis Using Laplace Transforms** Introduction to Laplace Transform, Laplace transform of standard input signals, Initial value and final value theorem, Inverse Laplace transform, Solution of differential equations using Laplace transform, s-Domain equivalents of circuit elements, The s-Domain equivalent circuit, Total response of first order and second order circuits using s-Domain equivalent circuit, Introduction of transfer function, Concept of Poles and Zeros, Transfer function representation of electrical circuits.	09	25
5	**Two Port Network and Network Functions** Introduction to Two Port Networks, relationship of two port variables, Short-circuit admittance parameter, Open-circuit impedance parameter, Transmission Parameter, Hybrid Parameter, Relationships between parameters, Parallel connection of two-port networks.	10	15
	TOTAL	**45**	**100**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**10**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C:Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

- K.S. Suresh Kumar, "Electric Circuit Analysis", Pearson Publications, 2013.
- M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.
- Nimje and D. P. Kothari, "Electrical Circuit Analysis and synthesis", New Age InternationalPublications, 2017
- D. Roy Choudhury, "Networks and Systems", New Age International Publications, 1998.
- W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, 2013.
- K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education, 2004.
- K. V. V. Murthy and M. S. Kamath, "Basic Circuit Analysis", Jaico Publishers, 1999.

List of Experiments :

This is a suggestive list only:

(1) To verify the Superposition Theorem by comparing analytical and experimental results.
(2) To verify the Thevenin and Norton's theorems by comparing analytical and experimental results.
(3) To verify the maximum power transfer theorem by comparing analytical and experimental results.
(4) To verify the Superposition Theorem by comparing analytical and simulated results with dependent sources.
(5) To verify the Thevenin and Norton's theorems by comparing analytical and simulated results with dependent sources.
(6) To simulate and analyze the steady-state and transient time-response of series R-L circuit.
(7) To simulate and analyze the steady-state and transient time-response of series R-C circuit.
(8) To simulate and analyze the steady-state and transient time-response of series R-L-C circuit.
(9) To verify the analytical steady state solution of AC circuits using phasors with experimental

results

(10) To verify experimental results of open-circuit impedance parameter of a tow-port network with analytical results

(11) To verify experimental results of short-circuit parameter of a tow-port network with analytical results

(12) To verify experimental results of hybrid parameter of a tow-port network with analytical results

(13) To verify experimental results of transmission parameter of a tow-port network with analytical results

Major Equipment:

List of Open Source Software/learning website:

- Bhattacharya, T. K. *Network Analysis* [MOOC]. NPTEL-NOC. https://archive.nptel.ac.in/courses/108/105/108105159/
- De, N. K.,et. Al. . *Basic Electrical Technology* [Handout]. NPTEL Online Course. https://nptel.ac.in/courses/108105053

- **Activities suggested under self learning for Electrical Circuit Analysis**

Sr. No.	Name of the activity	No. of hours	Evaluation Criteria
1	Network Theorems	Verify Network Theorems via circuit simulation.	Based on the understanding of the simulation
2	Write simple MATLAB programs for circuit analysis	Introduction to MATLAB for engineering problem-solving	Based on the understanding of MATLAB
3	Network Theorems	Real-life Applications of Thevenin and Norton Theorems in Power Systems	Based on the type of application and explanation
4	Initial conditions	Modeling Initial Conditions using Simulation Tools	Based on the simulation tool used and explanation
5	Write simple MATLAB programs for circuit analysis using Laplace	Implementation of Laplace Transform in MATLAB for RLC Circuits	Based on the understanding of MATLAB

6	Write simple MATLAB programs for circuit analysis using Inverse Laplace	Implementation of Inverse Laplace in MATLAB for RLC Circuits	Based on the understanding of MATLAB
7	Write simple MATLAB programs for two port networks	Implementation of Two port network parameters in MATLAB for RLC Circuits	Based on the understanding of MATLAB
8	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
9	Technical Video based learning related to the Network Analysis	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
10	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
11.	Online Certification Courses (NPTEL / SWAYAM / Coursera / edX) In ECA	Complete one MOOC (Massive Open Online Course) from NPTEL/SWAYAM relevant to ECA-Electrical Engineering	Certificate + a 1-page summary or review presentation of the course. Certificate of the course
12	Complex problem solving in ECA	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
13	Real world case studies based learning in ECA	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14	Discussion on research paper based on ECA	5 research paper = 20 h	Summarize research paper and evaluation critical parameters
15	Poster/chart/power point preparation on ECA	Duration = 6 h	Based on poster/chart preparation and presentation skills

16	Working/non-working model on technical topics of ECA	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
17	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
18	Group Discussion on emerging/trending technical topics based on ECA	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
19	Involvement in Student Chapter Activities (IEEE/ISTE/IEI)	Organizing student chapter activities/workshops (5h)+ Report /writing articles for the chapter newsletter(5h)	Based on short activity report and reflection
20	Industry Visit and Report Preparation	Attend an industry visit (e.g., to a substation, manufacturing unit, renewable energy plant) and prepare a detailed report.	Based on the report
22	Mini Project or DIY Challenge in ECA	Undertake a small home-based or simulation-based project (10 h)	Based on application of theoretical knowledge in practice.

Note:

1. All the suggested activity should be related to the subject.
2. 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.
3. Rubrics for the evaluation can be prepared by the faculty.
4. 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.
5. 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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