LEAD CITY UNIVERSITY, IBADAN
FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SEMESTER/SESSION: FIRST SEMESTER, 2024/2025

Course Particulars
Course Code: EEE 524
Course Title: Advance Circuit Theory
Course Unit: 3
Course Status: Compulsory

Lecturer's Details

Name: ZUBAIR, Abdul Rasak
Qualifications: B.Sc. (Electrical Engineering), M.Sc. (Electrical Engineering), Ph.D (Electrical and Electronic Engineering), MNSE, MIEEE, Registered Engr. (COREN)
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Areas of Specialization
Digital Signal Processing, Digital Image Processing, Engineering in Medicine and Renewable Energy

Course Synopsis
Computer - Aided Analysis / Design of Electric Network; Component / Device Modeling of Linear Network; Equation formulation (Nodal Method); Equation solution methods; Algorithm and program for automated solution; Operation count; Numerical inaccuracies, Pivoting and Sparsity; Sensitivity analysis; Non-linear networks – Taylor's theorem and Companion models.

Course Objectives
The course objectives are to expose students to;
- Circuit analysis using Spice
- Nodal and Mesh Analysis of Electric Circuits
- Circuit element models in the *s*-domain
- Electric circuit analysis in the s-domain
- The transfer function and State-space models applicable for electrical network
- Algorithm and Program for Automated Solution
- Sensitivity analysis of the electrical network gain to parameter variations model

Lecture Delivery Method
- Lectures with interactive sessions
- Solutions to examples problems

Course Learning Outcomes (CLOs)

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

1. Familiarized with basic computer analysis using Spice (Simulation Program with Integrated Circuit Emphasis).
2. Develop an understanding of how to use Kirchhoff's current law to write nodal equations and then to solve for unknown node voltages.
3. Develop an understanding of how to use Kirchhoff's voltage law to write mesh equations and then to solve for unknown loop currents.
4. Understand and use effectively circuit element models in the *s*-domain.
5. Understand what a transfer function is and how it is used.
6. Understand state variables and how to apply and use them in circuit analysis.
7. Understand algorithm and program for automated solution.
8. Understand the sensitivity of the electrical network gain to parameter variations.

Lecture Delivery Method

- Lecture with interactive sessions

LECTURE PLAN

Course Modules

Module 1: Computer analysis using Spice
Module 2: Nodal and Mesh Analysis of Electric Circuits
Module 3: Circuit element models and application of Laplace transformation technique in Electric Circuits Analysis
Module 4: Transfer function and State-space models applicable for electrical network
Module 5: Algorithm and program for automated solution / sensitivity analysis of the electrical network gain to parameter variations model

Course Outline

Module 1: Computer analysis using Spice; Nodal and Mesh Analysis of Electric Circuits

Number of Lecture Hours: 9

Week	Lecture Topic	Contents	Learning Objectives
1	Introduction	Spice basics, types of analysis, and circuit description	Understand PSpice basics, types of analysis, and circuit description.
2	Dissecting a Spice source file	Title Statement; .END Statement; Data Statements; Control/ Output Statements	Understand circuit files, device statement, control statement and Spice output.
3	DC Analysis	Resistors, Capacitors, Inductor, independent voltage and current sources, and dependent voltage and current sources; Data Statements and DC Analysis; Control and Output Statements in DC Analysis	• Understand different passive components, independent voltage and current sources and dependent voltage and current sources • Understand Data Statements and DC Analysis • Understand Control and Output Statements in DC Analysis

Module 2: Nodal and Mesh Analysis of Electric Circuits

Number of Lecture Hours: 6

4	Nodal analysis of electric circuits	Nodal Analysis with Voltage Sources	Understanding of how nodal analysis can be apply to circuits containing voltage sources (dependent or independent)
5	Mesh analysis of electric circuits	Mesh analysis with Current Sources	Understanding of how mesh analysis can be apply to circuits containing current sources (dependent or independent
6	Test		Continuous Assessment

Module 3: Circuit element models and application of Laplace transformation technique in Electric Circuits Analysis

Number of Lecture Hours: 9

Week	Lecture Topic	Contents	Learning Objectives
7	Circuit element models	Time-domain and *s*-domain representations of passive elements under zero initial conditions.	Understand electric circuit element models
8	Circuit analysis in the *s*-domain	Application of Laplace transformation technique in Electric Circuits Analysis	Understand and use effectively circuit element models in the *s*-domain
9	Mid-semester Test		Continuous Assessment

Module 4: Transfer function and State-space models applicable for electrical network

Number of Lecture Hours: 6

Week	Lecture Topic	Contents	Learning Objectives
10	Transfer function	Transfer function of a network	Understand what a transfer function is and how it is used.
11	State variable analysis	State space models applicable for electrical circuits	Understand state variables and how to apply and use them in circuit analysis
12	Test		Continuous Assessment

Module 5: Algorithm and program for automated solution / sensitivity analysis of the electrical network gain to parameter variations model

Number of Lecture Hours: 9

Week	Lecture Topic	Contents	Learning Objectives
13	Algorithm/program for automated solution	Algorithm for automated solution	Understand algorithm and program for automated solution.
14	Sensitivity analysis	Sensitivity analysis of the electrical network	Understand the sensitivity of the electrical network gain to parameter variations
15	Revision and Test		Continuous Assessment.

Grading System

This course will be graded as follows:

Attendance:	10%
CA/Assignments:	30%
Examination:	60%
Total:	**100%**

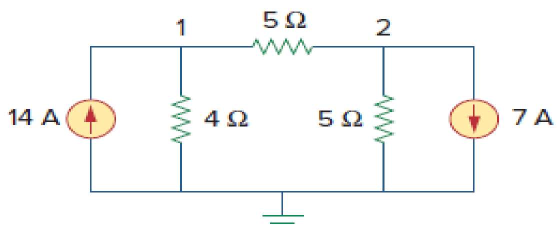
References

(i) Chakrabarti: Circuit Theory (Analysis and Synthesis), Fifth Edition Published by Dhanpat Rai & Co. (PVT) LTD

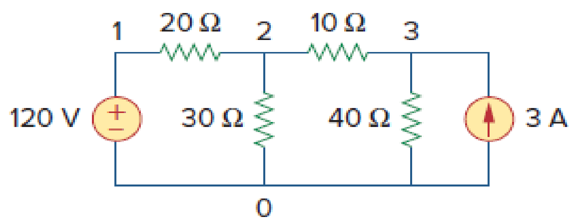
(ii) Charles K. Alexander and Matthew N. O. Sadiku: Fundamentals of Electric Circuits, Sixth Edition Published by McGraw-Hill Education

EEE 524 Tutorial Questions

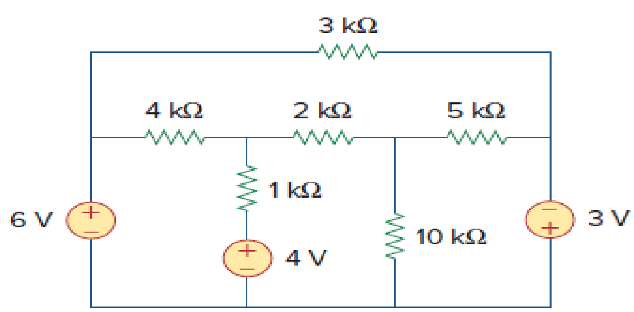
Q1) For the circuit of Figure Q1(a, b, and c), write the PSpice program. **15 Marks**



(a)



(b)



(c)

Figure Q1 (a, b, and c)

Q2) Calculate the node voltages in the circuit shown in Figure Q2. **15 Marks**

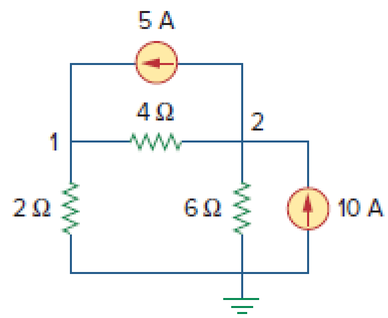


Figure Q2

Q3) Determine the voltages at the nodes in Figure Q3. **15 Marks**

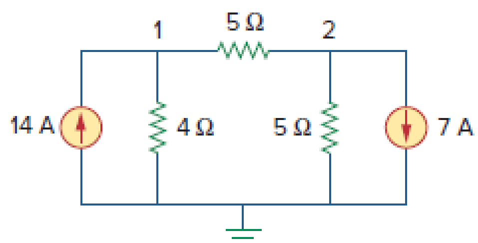


Figure Q3

Q4) For the circuit shown in Figure Q4, find the node voltages. **15 Marks**

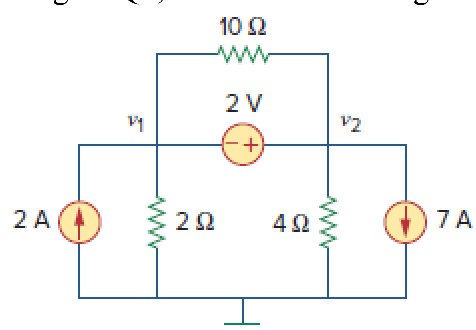


Figure Q4

Q5) Use mesh analysis to find the current I_o in the circuit of Figure Q5. **15 Marks**

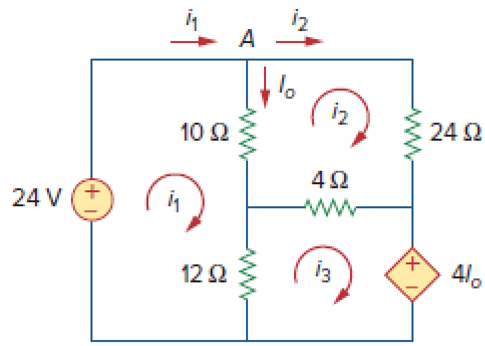


Figure Q5

Q6) For the circuit in Figure Q6, find i_1 to i_4 using mesh analysis. **15 Marks**

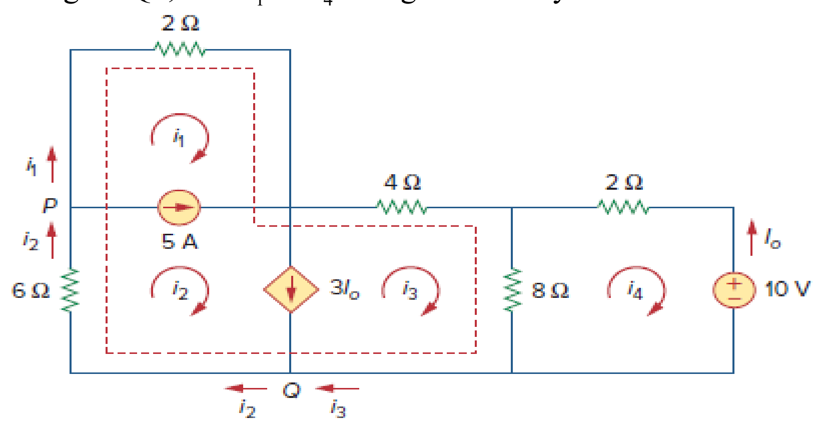


Figure Q6

Q7) (a) Determine the Laplace transform of each of the following functions:

(i) $u(t)$

(ii) $e^{-at}u(t), a \geq 0$

(iii) $\delta(t)$

(b) Determine the Laplace transform of $f(t) = \sin \omega t\, u(t)$.

15 Marks

Q8) (a) Find $f(t)$ given that

$$F(s) = \frac{s^2 + 12}{s(s+2)(s+3)}$$

(b) Calculate $v(t)$ given that

$$V(s) = \frac{10s^2 + 4}{s(s+1)(s+2)^2}$$

(c) Use the Laplace transforms to solve the differential equation

$$\frac{d^2v(t)}{dt^2} + 6\frac{dv(t)}{dt} + 8v(t) = 2u(t)$$

subject to $v(0) = 1$, $v'(0) = -2$

15 Marks

Q9) (a) Find $v_o(t)$ in the circuit of Figure Q9(a), assuming zero initial conditions.

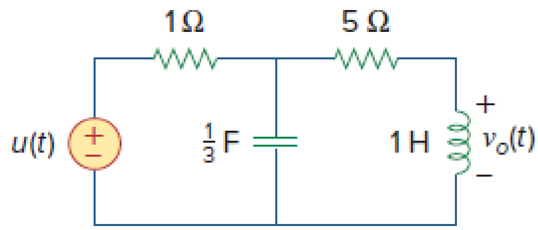


Figure Q9(a)

(b) Find $v_o(t)$ in the circuit of Figure Q9(b). Assume $v_o(0) = 5\text{V}$.

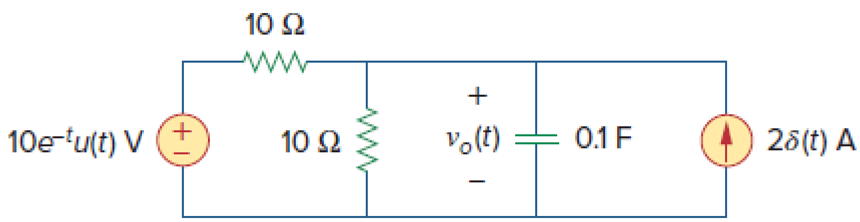


Figure Q9(b)

15 Marks

Q10) (a) In the circuit of Figure Q10 (a), the switch moves from position a to position b at $t = 0$. Find $i(t)$ for $t > 0$.

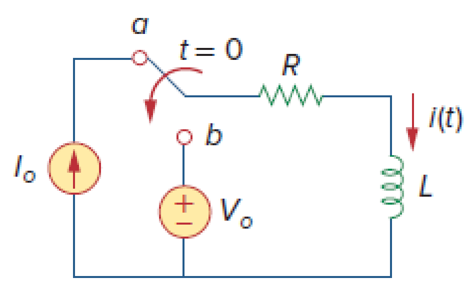


Figure Q10 (a)

(b) Consider the circuit in Figure Q10 (b). Find the value of the voltage across the capacitor assuming that the value of $v_s(t) = 10u(t)$ V and assume that at $t = 0, -1$ A flows through the inductor and $+5$ V is across the capacitor.

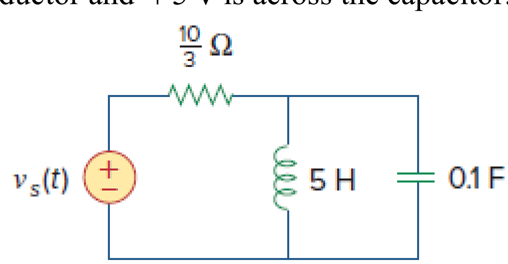


Figure Q10 (b)

15 Marks

Q11) The output of a linear system is $y(t) = 10e^{-t}\cos 4t\, u(t)$ when the input is $x(t) = e^{-t}u(t)$. Find the transfer function of the system and its impulse response.

15 Marks

Q12) Determine the transfer function $H(s) = V_o(s)/I_o(s)$ of the circuit in Figure Q12.

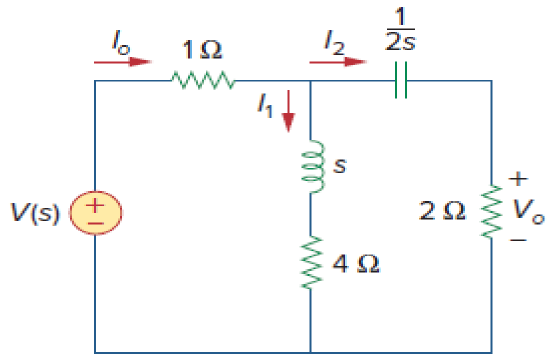


Figure Q12

15 Marks

Q13) For the s-domain circuit in Figure Q13, find: (a) the transfer function $H(s) = V_o/V_i$, (b) the impulse response, (c) the response when $v_i(t) = u(t)$ V, (d) the response when $v_i(t) = 8\cos 2t$ V.

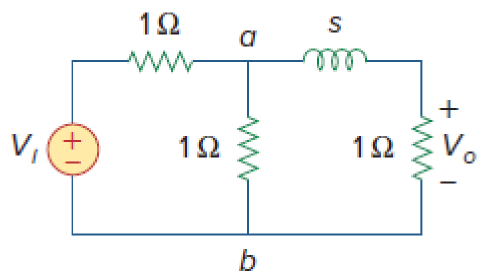


Figure Q13

15 Marks

Q14) Find the state-space representation of the circuit in Figure Q14. Determine the transfer function of the circuit when v_s is the input and i_x is the output. Take R = 1 Ω, C = 0.25 F, and L = 0.5 H.

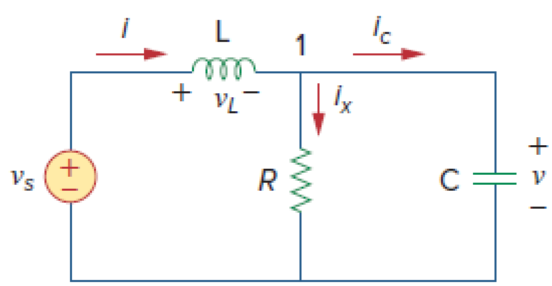


Figure Q14

15 Marks

Q15) (a) Determine the Laplace transform of each of the following functions:

(i) $u(t)$

(ii) $e^{-at}u(t), a \geq 0$

(iii) $\delta(t)$

(b) Determine the Laplace transform of $f(t) = \sin\, \omega t\, u(t)$.

15 Marks