MATHEMATICAL QUESTIONS

Question 1

The linear rime-invariant network shown in Fig. 1 is in the sinusoidal steady state. The coupling between the inductors is specified by the reciprocal inductance matrix

$$\begin{bmatrix} \Gamma_0 & \Gamma_1 & \Gamma_2 & 0 \\ \Gamma_1 & \Gamma_0 & \Gamma_1 & \Gamma_2 \\ \Gamma_2 & \Gamma_1 & \Gamma_0 & \Gamma_1 \\ 0 & \Gamma_2 & \Gamma_1 & \Gamma_0 \end{bmatrix}$$

Write the cut-set equations $\boldsymbol{Y}_q(j\omega)\boldsymbol{E} = \boldsymbol{I}_s$ and the node equations $\boldsymbol{Y}_n(j\omega)\boldsymbol{E} = \boldsymbol{I}_s$ in matrix form.

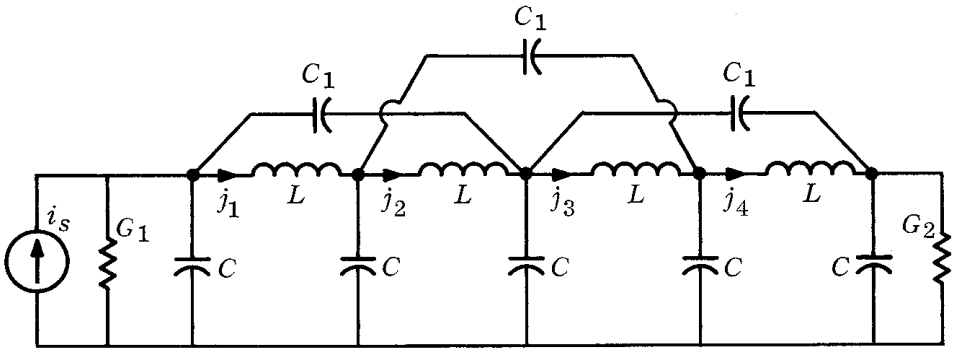

Figure 1: A coupled circuit.

Question 2

The linear time-invariant network of Fig. 2, having the shown topological graph, is in the sinusoidal steady state. From the topological graph, the highlighted tree is picked.

Question 2 continued on next page...

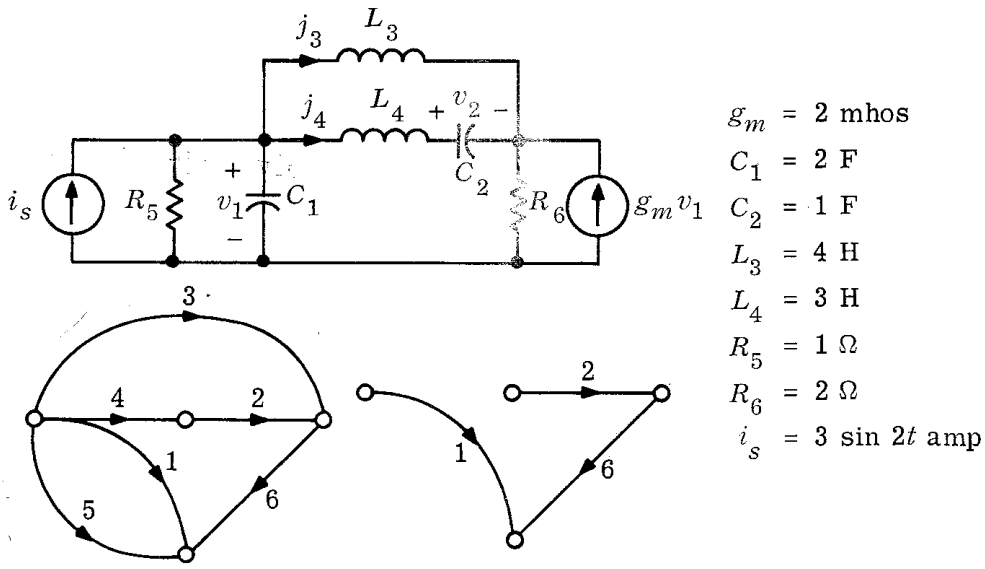

Figure 2: An LTI circuit along with its topological graph and spanning tree.

(a) Write tho fundamental loop matrix $\boldsymbol{B}$.

(b) Calculate the loop impedance matrix $\boldsymbol{Z}_l$.

(c) Write the loop equations in terms of voltage and current phasors, that is, $\boldsymbol{Z}_l\boldsymbol{I} = \boldsymbol{E}_s$.

(d) Write the matrix equations required to calculate the branch voltages and branch currents.

Question 3

Which loop impedance matrix below does belong to a passive LTI RLC circuit? Give your reasons for rejecting any.

$$\begin{bmatrix} 3 & 2 \\ 2 & 5 \end{bmatrix}, \quad \begin{bmatrix} -1 & 2 \\ 2 & 4 \end{bmatrix}, \quad \begin{bmatrix} 1 & 2 \\ 2 & 3 \end{bmatrix}$$

$$\begin{bmatrix} 3+j & -2j \\ -2j & 5+7j \end{bmatrix}, \quad \begin{bmatrix} 3 & -j \\ -j & 2 \end{bmatrix}, \quad \begin{bmatrix} 5 & 7j \\ 6j & 8+3j \end{bmatrix}$$

Question 4

For the circuit of Fig. 3,

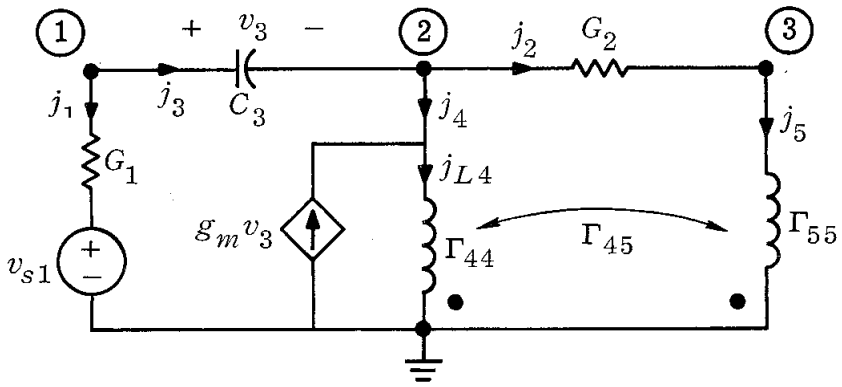

Figure 3: An LTI circuit for which the modified node analysis equations are required.

(a) Write the modified node analysis equations in Laplace domain.

(b) Write the modified node analysis equations in time domain.

(c) Write the modified node analysis equations in Phasor domain.

Question 5

For the circuit if Fig. 4,

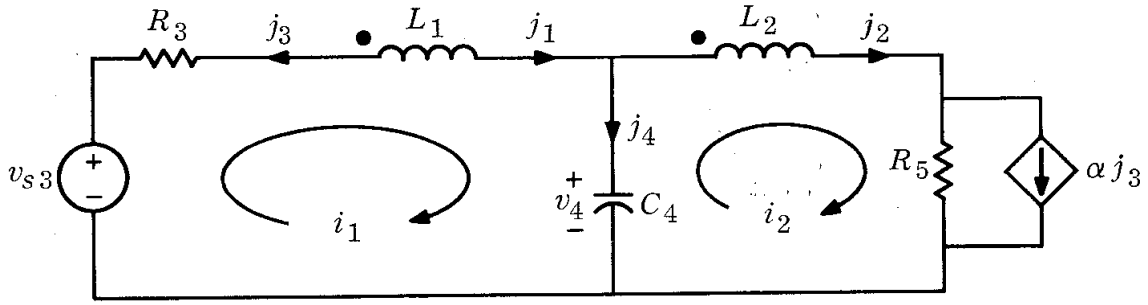

Figure 4: An LTI circuit for which the loop and mesh equations are required.

Question 5 continued on next page...

(a) Write the systematic loop equations in Laplace domain.

(b) Write the systematic mesh equations in Phasor domain.

(c) Write the shortcut mesh equations in time, phasor, and Laplace domains.

SOFTWARE QUESTIONS

Question 6

Write a MATLAB function that returns the time-domain solution of the Laplace matrix equation $\boldsymbol{A}(s)\boldsymbol{X}(s) = \boldsymbol{I}(s)$, where $\boldsymbol{A}(s)$ is a square matrix whose elements are polynomials of s and $\boldsymbol{I}(s)$ is a vector whose elements are real fractional functions of s. You might use the symbolic math features of MATLAB.

BONUS QUESTIONS

Question 7

Return your answers by filling the LaTeXtemplate of the assignment. If you want to add a circuit schematic, you can draw it directly using TikZ package, or draw it in a secondary application such as Microsoft Visio and then, import it as a figure.

EXTRA QUESTIONS

Question 8 continued on next page...

Question 8

Feel free to solve the following questions from the book *"Basic Circuit Theory"* by C. Desoer and E. Kuh.

1. **Chapter 10, question 5.**
2. **Chapter 10, question 6.**
3. **Chapter 10, question 7.**
4. **Chapter 10, question 8.**
5. **Chapter 10, question 12.**
6. **Chapter 10, question 13.**
7. **Chapter 10, question 14.**
8. **Chapter 11, question 5.**
9. **Chapter 11, question 8.**