EE1101: Circuits and Network Analysis

Assignment - 09

Handed out: 04 - Oct - 2024 **Due : 15 - Oct - 2024 (before 5 PM)**

Instructions :

1. Please upload your assignment solutions to the course page on the Canvas platform. Only solutions submitted through canvas will be reviewed. For specific guidelines, refer to the instructions provided on the course page.
2. It is suggested that you attempt all the problems. However, it is sufficient to submit solutions for problems that total 10 points.
3. Submissions received after the deadline will attract negative marking. Ensure that your submissions are named in the following format: RollNo-Assignment-09.pdf.

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1. (16 points) Consider the circuit shown in Fig. 1[1].

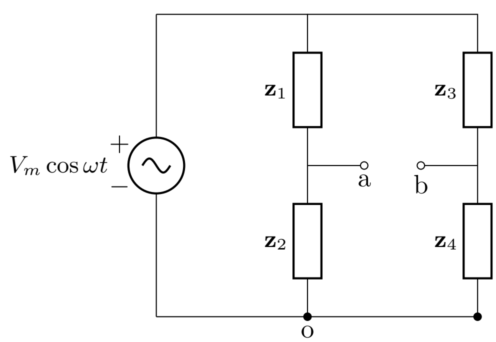

Fig. 1: Generic Bridge Circuit (Question 1)

(a) (4 points) Show that the condition under which the potential between nodes a and b is zero (under steady state) is $\mathbf{z}_1\mathbf{z}_4 = \mathbf{z}_2\mathbf{z}_3$.

(b) (4 points) Let $\mathbf{z}_1$ and $\mathbf{z}_3$ represent resistors, specifically $\mathbf{z}_1 = R_1$ and $\mathbf{z}_3 = R_3$. Additionally, let $\mathbf{z}_2$ and $\mathbf{z}_4$ represent the equivalent impedance of series RL branches, such that $\mathbf{z}_2 = R_2 + j\omega L_2$ and $\mathbf{z}_4 = R_4 + j\omega L_4$. Assume the values of R_1, R_2, R_3, R_4 and L_2 are known, while L_4 is the value to be determined. Furthermore, assume R_1 and R_2 are selected (or ideally adjusted) so that the potential difference between nodes a and b is zero. Derive an expression for L_4 in terms of the other circuit element values.

(c) (4 points) The typical Hay's bridge circuit (used for inductance measurement) has the structure of circuit shown in Fig. 1 with $\mathbf{z}_1$ corresponding to a series RC branch i.e., $\mathbf{z}_1 = R_1 + \frac{1}{j\omega C_1}$, $\mathbf{z}_2$ and $\mathbf{z}_3$ corresponding to a resistor i.e., $\mathbf{z}_2 = R_2$ and $\mathbf{z}_3 = R_3$ and $\mathbf{z}_1$ corresponding to a series RL branch i.e., $\mathbf{z}_4 = R_4 + j\omega L_4$. Assume

[1]The circuits covered as a part of this problem are referred to as AC bridge circuits, often used to measure the values of unknown circuit elements and frequency

the values of R_1, R_2, R_3 and L_2 are known, while R_4, L_4 needs to be determined. Furthermore, assume R_1 and R_2 are selected (or ideally adjusted) so that the potential difference between nodes a and b is zero. Derive an expression for R_4 and L_4 in terms of the other circuit element values.

(d) (4 points) The typical Maxwell's bridge circuit (used for inductance measurement) has the structure of circuit shown in Fig. 1 with $\mathbf{z}_1$ corresponding to a parallel RC branch i.e., $\mathbf{z}_1 = R_1 || \frac{1}{j\omega C_1}$, $\mathbf{z}_2$ and $\mathbf{z}_3$ corresponding to a resistor i.e., $\mathbf{z}_2 = R_2$ and $\mathbf{z}_3 = R_3$ and $\mathbf{z}_1$ corresponding to a series RL branch i.e., $\mathbf{z}_4 = R_4 + j\omega L_4$. Assume the values of R_1, R_2, R_3 and L_2 are known, while R_4, L_4 needs to be determined. Furthermore, assume R_1 and R_2 are selected (or ideally adjusted) so that the potential difference between nodes a and b is zero. Derive an expression for R_4 and L_4 in terms of the other circuit element values.

2. (10 points) Consider the circuit shown in Fig. 2.

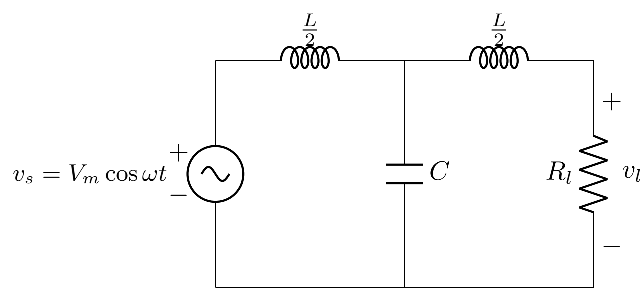

Fig. 2: Circuit for Analysis (Question 2)

(a) (4 points) Establish a condition for the value of R such that the peak value of v_l exceeds V_m (if such a condition exists).

(b) (6 points) Compute the steady state voltage across R_l when $V_m = 100$ V, $L = 1$ mH, $C = 1$mF, $R_l = 10\Omega$ and $\omega = 100\pi$. Represent the drop across each circuit element on a phasor diagram. Further, compute the complex power associated with the voltage source.

3. (8 points) Consider the circuit shown in Fig. 3.

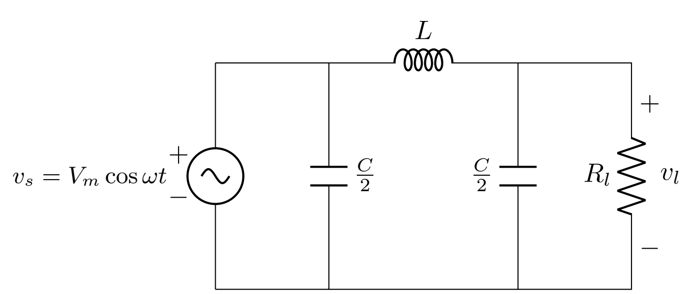

Fig. 3: Circuit for Analysis (Question 3)

(a) (4 points) Establish a condition for the value of R such that the peak value of v_l exceeds V_m (if such a condition exists).

(b) (4 points) Compute the steady state voltage across R_l when $V_m = 100$ V, $L = 1$ mH, $C = 1$mF, $R_l = 10\Omega$ and $\omega = 100\pi$. Represent the drop across each circuit element on a phasor diagram.

4. (4 points) Consider the circuit shown in Fig. 4. Compute the steady state voltage across R_l when $V_m = 100$ V, $L = 1$ mH, $C = 1$mF, $R_l = 10\Omega$ and $\omega = 100\pi$.

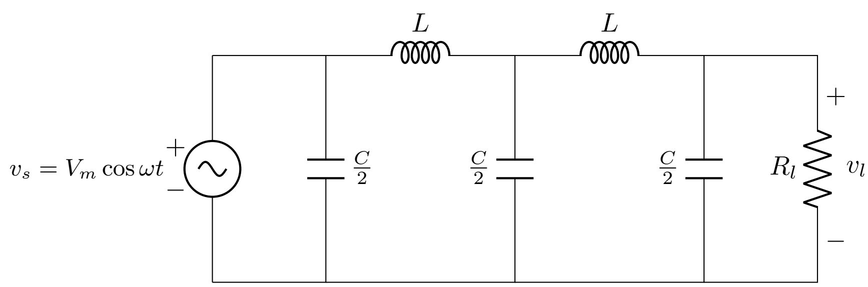

Fig. 4: Circuit for Analysis (Question 4)

5. (4 points) Consider the circuit shown in Fig. 5. Compute the steady state voltage across R_l when $V_m = 100$ V, $R_1 = R_2 = 1\Omega$, $L_1 = L_2 = 1$ mH, $L_0 = 10$ mH, $R_l = 10\Omega$ and $\omega = 100\pi$.

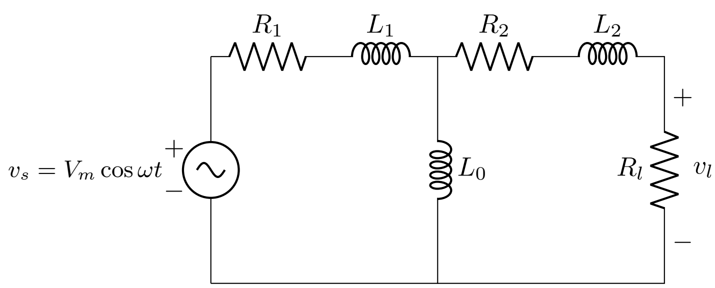

Fig. 5: Circuit for Analysis (Question 5)

6. (4 points) Consider the circuit shown in Fig. 6. If the voltage v_l and the current though the branch in steady state

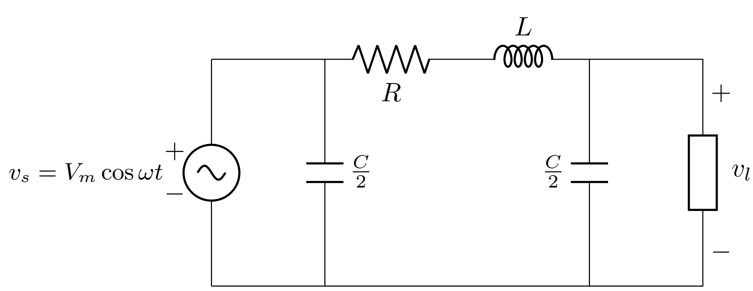

Fig. 6: Circuit for Analysis (Question 6)

is given by $\mathbf{V}_r$ and $\mathbf{I}_r$ respectively, compute the complex power associated with the source and the load. The values of circuit elements are $V_m = 100$, $\omega = 100\pi$, $R = 1\Omega$, $L = 1$mH, $C = 1$mF and $R_l = 10\Omega$.