GATE 22 IN/63

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QUESTION: The bridge shown is balanced when $R_1 = 100\Omega, R_2 = 210\Omega, C_2 = 2.9\mu F, R_4 = 50\Omega$. The 2kHz sine-wave generator supplies a voltage of $10V_{p-p}$. The value of L_3(in mH) is?

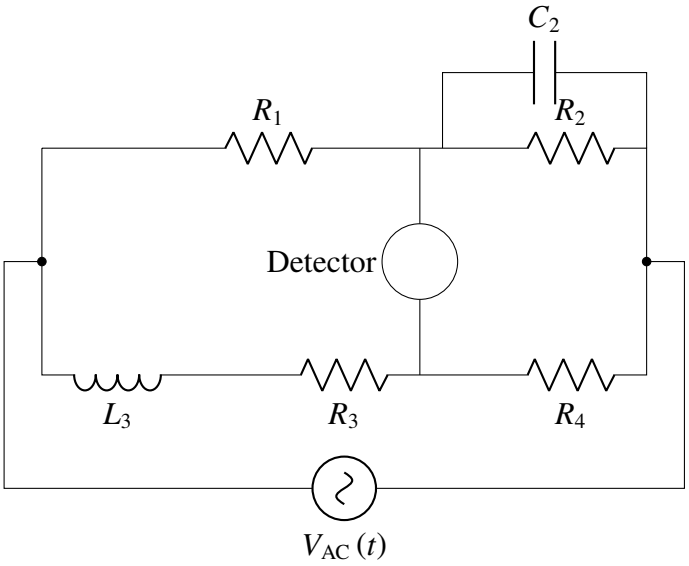

Fig. 1. Circuit in T domain

Solution:

Variables	Description	value
R_1	Resistor 1	100Ω
R_2	Resistor 2	210Ω
R_3	Resistor 3	?
R_4	Resistor 4	50Ω
C_2	Capacitor 2	$2.9\mu F$
L_3	Inductor 3	?

TABLE 1
CAPTION

The circuit in S domain is

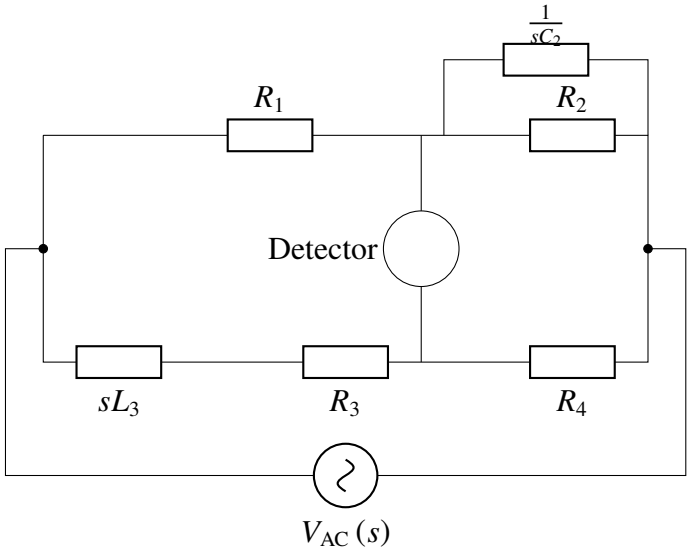

Fig. 2. Circuit in S domain

Applying Wheatstone bridge condition,

$$\frac{R_1}{sL_3 + R_3} = \frac{\frac{1}{\frac{1}{R_2} + sC_2}}{R_4} \tag{1}$$

$$\implies \frac{R_1}{sL_3 + R_3} = \frac{1}{\left(\frac{1}{R_2} + sC_2\right)R_4} \tag{2}$$

$$\implies \frac{sL_3 + R_3}{R_1} = \left(\frac{1}{R_2} + sC_2\right)R_4 \tag{3}$$

$$\implies \frac{sL_3}{R_1} + \frac{R_3}{R_1} = \frac{R_4}{R_2} + sC_2R_4 \tag{4}$$

Comparing coefficients, we get

$$\frac{L_3}{R_1} = C_2R_4 \tag{5}$$

$$\implies L_3 = R_1C_2R_4 \tag{6}$$

$$\frac{R_3}{R_1} = \frac{R_4}{R_2} \tag{7}$$

$$\implies R_3 = \frac{R_1R_4}{R_2} \tag{8}$$

From Table 1, substituting in (6) and (8), we get

$$L_3 = 14.5mH \tag{9}$$

$$R_3 = 23.80\Omega \tag{10}$$