

task_pdkggyexxy1ktu3_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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Exercise E13 Impedances at different Frequencies

(written test, approx. 18 % of a 60-minute written test, WS2022)

2. A series circuit consists of a resistor $R_1 = 1.00 \text{ k}\Omega$, an inductor $L = 4.7 \text{ }\mu\text{H}$, and a capacitor $C = 40 \text{ nF}$. The circuit is connected to an AC voltage source $U = 10 \text{ V}$ at a frequency $f = 4 \text{ MHz}$. Calculate the absolute value of the impedance $|Z|$ of the circuit.

Solution

Solution: $R_1 = 1.00 \text{ k}\Omega$
 $R_2 = 10.0 \text{ }\Omega$

A series circuit means that the current is constant on every component.

The equivalent impedance for R and L combined is given by $\underline{Z} = R + jX_L$

Parallel circuit means that the voltage is the same on R and C .
 $\underline{Z} = R \parallel jX_C = \frac{R \cdot jX_C}{R + jX_C}$
 $\underline{Z} = \frac{R \cdot jX_C}{R + jX_C} \cdot \frac{R - jX_C}{R - jX_C} = \frac{R \cdot jX_C (R - jX_C)}{R^2 + X_C^2}$

$\underline{Z} = \frac{R \cdot jX_C (R - jX_C)}{R^2 + X_C^2} = \frac{R \cdot jX_C R - R \cdot jX_C jX_C}{R^2 + X_C^2} = \frac{R^2 X_C + X_C^3}{R^2 + X_C^2}$
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Therefore, the resulting current of the parallel circuit is given as: $I = \frac{U}{|Z|}$

$I = \frac{U}{|Z|} = \frac{U}{\sqrt{R^2 + X_C^2}} = \frac{10 \text{ V}}{\sqrt{1.00^2 + 10.0^2}} = 0.099 \text{ A} = 99 \text{ mA}$

Back to the first formula: $\underline{Z} = R + jX_L = 1.00 \text{ k}\Omega + j10.0 \text{ }\Omega$

$|Z| = \sqrt{R^2 + X_L^2} = \sqrt{1.00^2 + 10.0^2} = 10.0 \text{ k}\Omega$
 $I = \frac{U}{|Z|} = \frac{10 \text{ V}}{10.0 \text{ k}\Omega} = 1.00 \text{ mA}$

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