

task_kricv9fh7haauo6q_with_calculation

Student Group

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complex impedance, exam WS2022

Exercise 1 : Complex Impedance Circuit

(written test, approx. 15% of a 60-minute written test, WS2022)

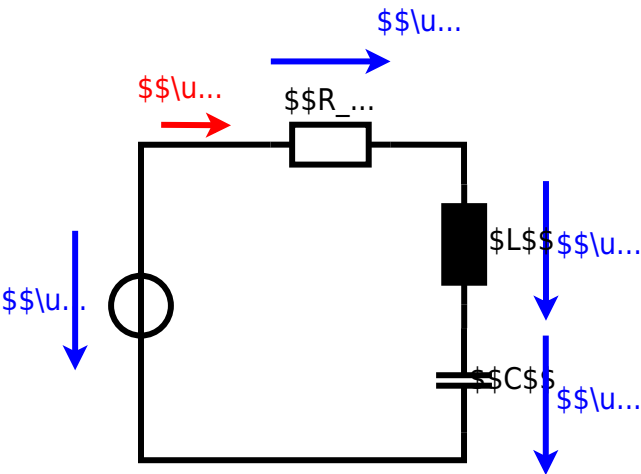
A circuit designed to filter the noise from a signal shall be analysed.

The input is given by a voltage source $u(t) = 3.0 \text{ V} \cdot \sin(2\pi \cdot 15 \text{ kHz} \cdot t)$ with an internal resistance of $10 \text{ } \Omega$.

This linear source is connected with an inductor of $330 \text{ } \mu\text{H}$ and a capacitor of $0.22 \text{ } \mu\text{F}$, all in series.

1. Draw the circuit diagram of the given circuit.
Label all components, voltages and currents.

Result



2. Calculate the single impedance $\underline{Z}_C$, $\underline{Z}_L$ such as $\underline{Z}$ of the overall circuit.

Solution

$$\begin{aligned} Z_C &= \frac{1}{2\pi \cdot f \cdot C} = \frac{1}{2\pi \cdot 15 \text{ kHz} \cdot 0.22 \text{ } \mu\text{F}} \\ Z_L &= 2\pi \cdot f \cdot L = 2\pi \cdot 15 \text{ kHz} \cdot 0.22 \text{ } \mu\text{H} \\ Z_C &= \frac{1}{2\pi \cdot 15 \text{ kHz} \cdot 0.22 \text{ } \mu\text{F}} \\ Z_C &= \frac{1}{2\pi \cdot 15 \text{ kHz} \cdot 0.22 \text{ } \mu\text{F}} \\ \underline{Z} &= R + \underline{Z}_L + \underline{Z}_C = R + j \cdot \underline{Z}_L - j \cdot \underline{Z}_C = R + j \cdot (\underline{Z}_L - \underline{Z}_C) \\ |\underline{Z}| &= \sqrt{R^2 + (\underline{Z}_L - \underline{Z}_C)^2} \end{aligned}$$

Final result

$$\begin{aligned} Z_L &= 31.1 \text{ } \Omega \\ Z_C &= 48.2 \text{ } \Omega \\ Z &= 19.8 \text{ } \Omega \end{aligned}$$

3. Draw the three impedance phasors $\underline{Z}_C$, $\underline{Z}_L$ and $\underline{Z}$ in a diagram.
Choose an appropriate scaling factor and write it down.

Result

4. Calculate the current $\underline{I}$.

Solution

$$\begin{aligned} Z &= \frac{\hat{U}}{\hat{I}} \quad \hat{I} = \frac{\hat{U}}{Z} \end{aligned}$$

With $I = \frac{1}{\sqrt{2}} \cdot \hat{I}$:
$$\frac{1}{\sqrt{2}} \cdot \frac{\hat{U}}{Z} = \frac{1}{\sqrt{2}} \cdot \frac{3.0 \text{ V}}{19.28 \text{ } \Omega}$$

Final result

$$I = 107 \text{ mA}$$

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