

task_pdkggtyexxy1ktu3_with_calculation

Student Group

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Exercise E8 Impedances at different Frequencies
(written test, approx. 18 % of a 60-minute written test, WS2022)

A series circuit consists of a resistor $R_1 = 1.00 \text{ } \Omega$, an inductor $L = 4.7 \text{ } \mu\text{H}$, and a capacitor $C = 40 \text{ nF}$. The voltage across the resistor is $U_R = 10.0 \text{ V}$. The current through the resistor is $I = 10.0 \text{ mA}$. The voltage across the inductor is $U_L = 10.0 \text{ V}$. The voltage across the capacitor is $U_C = 10.0 \text{ V}$. The total voltage across the series circuit is $U = 30.0 \text{ V}$. The total impedance is $Z = 10.0 \text{ } \Omega$. The total current is $I = 10.0 \text{ mA}$. The total power is $P = 1.00 \text{ W}$.

Solution

$R_1 = 1.00 \text{ } \Omega$

$R_2 = 10.0 \text{ } \Omega$

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

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

Parallel circuit means that the voltage is the same on R_2 and C_2

$Z_{parallel} = \frac{R_2 \cdot X_C}{R_2 + X_C}$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \cdot 40 \cdot 10^{-9}} = 398 \text{ } \Omega$

$Z_{parallel} = \frac{10 \cdot 398}{10 + 398} = 9.75 \text{ } \Omega$

$Z_{total} = R_1 + Z_{parallel} = 1.00 + 9.75 = 10.75 \text{ } \Omega$

Therefore, the resulting current of the parallel circuit is given as:

$I_{parallel} = \frac{U_{parallel}}{Z_{parallel}} = \frac{10.0}{9.75} = 1.03 \text{ A}$

This current is the current through the resistor R_2

$I_{R2} = 1.03 \text{ A}$

Back to the first formula: $R_3 \cdot I_{R3} = X_{C3} \cdot I_{C3}$

$R_3 = \frac{X_{C3} \cdot I_{C3}}{I_{R3}} = \frac{398 \cdot 1.03}{1.03} = 398 \text{ } \Omega$

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