task_pdkggtyexxy1ktu3_with_calculation

Student Group

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complex impedance, exam ee1 WS2022

Exercise E13 Impedances at different Frequencies
(written test, approx. 18 % of a 60-minute written test, WS2022)

2. A RLC series circuit with the resistor values $R_2=34.7 ~\Omega$ and $L_2=21.0 ~{\rm µH}$ shall be connected to a voltage source with $U_3=1.0 ~{\rm V}$, which generates a current $I_3=50 ~{\rm mA}$.
Back to the first formula: $$R_3 \cdot {I}_{3R} = {X}_{3C} \cdot {I}_{3C}$$
$$R_3 = {X}_{3C} \cdot {{I}_{3C}\over{I}_{3R}} = {{1}\over{2\pi \cdot f \cdot C_3}} \cdot {{\sqrt{|{I}_{3}|^2 - |{I}_{3R}|^2}}\over{{I}_{3R}}}$$
Result: $R_3 = 2.0 ~{\rm kΩ}$

1. A resistor R_1 shall have the same absolute value of the impedance as a capacitor R_3.
$C_1=40 ~{\rm nF}$ at $f_1=4 ~{\rm MHz}$.

Solution

Solution

Solution

$$R_1 = 1.00 ~\Omega$$

$$R_3 = 10.0 ~\Omega$$

A series circuit means that the current is constant on every component.
The equivalent impedance for R and L combined is given by $$\underline{Z} = R + \underline{X}_{L2} = R + \mathrm{j} \cdot \omega L$$ Since $\underline{X}_{C1} = -\mathrm{j} \cdot \frac{1}{\omega C}$ is perpendicular to $\underline{X}_{L2}$ this can be simplified to: $$|\underline{Z}|^2 = R^2 + |\underline{X}_{L2}|^2$$ It gets clear that $\underline{I}_{3R}$ is perpendicular to $\underline{I}_{3C}$ (It has to, since R_3 is perpendicular to ${\rm j}\cdot{X}_{3C}$ too).
Therefore, the resulting current of the parallel circuit is given as: $$\underline{I}_{3} = \underline{I}_{3R} + \underline{I}_{3C}$$
$$|\underline{I}_{3}|^2 = |\underline{I}_{3R}|^2 + |\underline{I}_{3C}|^2$$
$$|\underline{I}_{3R}| = \sqrt{|\underline{I}_{3}|^2 - |\underline{I}_{3C}|^2}$$
$$|\underline{I}_{3R}| = \sqrt{\left|{{U}\over{I}}\right|^2 - (2\pi \cdot 450~{\rm kHz} \cdot 4.7 ~ {\rm µH})^2 }$$
Back to the first formula: $$R_3 \cdot {I}_{3R} = {X}_{3C} \cdot {I}_{3C}$$
$$R_3 = {X}_{3C} \cdot {{I}_{3C}\over{I}_{3R}} = {{1}\over{2\pi \cdot f \cdot C_3}} \cdot {{\sqrt{|{I}_{3}|^2 - |{I}_{3R}|^2}}\over{{I}_{3R}}}$$