

task_pdkggtyexxy1ktu3_with_calculation

Student Group

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complex impedance, exam WS2022

Exercise 1 : Impedances at Frequencies

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

Calculate the **resistor values** which have to be used the following circuits.

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

Solution

$$R_1 = |\underline{X}_{C1}| = \frac{1}{2\pi \cdot f \cdot C_1} = \frac{1}{2\pi \cdot 4 \text{ MHz} \cdot 40 \text{ nF}}$$

Final result

$$R_1 = 1.00 \text{ } \Omega$$

2. A RL series circuit with $L_2=4.7 \text{ } \mu\text{H}$, where an AC voltage source of $U_2=1.0 \text{ V}$ with $f_2=450 \text{ kHz}$ generates a current $I_2=60 \text{ mA}$.

Solution

Series circuit means that the current is constant on every component.

The equivalent impedance for R and L combined is given by
$$\frac{\underline{U}}{\underline{I}} = R_2 + \underline{X}_{L2} = R_2 + j \cdot \omega L$$
 Since $j \cdot \omega L$ is perpendicular to R_2 this can be simplified to:
$$\left| \frac{\underline{U}}{\underline{I}} \right|^2 = |R_2|^2 + |\underline{X}_{L2}|^2 \quad \left| \frac{U}{I} \right|^2 = R_2^2 + X_{L2}^2$$

This can be rearranged to get R_2 :
$$R_2 = \sqrt{\left| \frac{U}{I} \right|^2 - X_{L2}^2} = \sqrt{\left(\frac{1\text{V}}{60\text{mA}} \right)^2 - (2\pi \cdot 450\text{kHz} \cdot 4.7 \text{ } \mu\text{H})^2}$$

Final result

$$R_2 = 10.0 \text{ } \Omega$$

3. A $\$RC\$$ parallel circuit with $\$C_3=4.7\text{ nF}\$$ on an AC current source ($\$I_{3S}=1.3\text{ A}\$, \$f_3=200\text{ kHz}\$$), which generates a current of $\$I_{3R}=1.0\text{ A}\$$ through $\$R_3\$$.

Solution

Parallel circuit means that the voltage is the same on $\$R_3\$$ and $\$C_3\$$:

$$\underline{U}_3 = R_3 \cdot \underline{I}_{3R} = -j \cdot X_{3C} \cdot \underline{I}_{3C}$$
 So it gets clear, that \underline{I}_{3R} is perpendicular to \underline{I}_{3C} (It has to, since R_3 is perpendicular to $-j \cdot X_{3C}$, too). Therefore, the resulting current of the parallel circuit is given as:

$$I_3 = \sqrt{I_{3R}^2 + I_{3C}^2} = \sqrt{I_{3R}^2 + \left(\frac{I_{3R}}{X_{3C}}\right)^2} = I_{3R} \cdot \sqrt{1 + \frac{1}{X_{3C}^2}}$$

Back on the first formula: $R_3 \cdot I_{3R} = X_{3C} \cdot I_{3C}$
 $R_3 = X_{3C} \cdot \frac{I_{3C}}{I_{3R}} = \frac{1}{2\pi \cdot f \cdot C_3} \cdot \frac{I_{3C}}{I_{3R}} = \frac{\sqrt{I_{3C}^2 - I_{3R}^2}}{I_{3R}}$

Final result

$R_3 = 70.0\ \Omega$

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