task_jti0uzudcmg4u22t_with_calculation

Student Group

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complex impedance, exam ee1 WS2022

Exercise E9 Analyzing complex Impedances
(written test, approx. 14 % of a 60-minute written test, WS2022)

2. Calculate the phase angle between the voltage and the current through the components.
3. Calculate the physical values of the two components.

Result

The analysis shall be performed for the impedance values measured at the given frequency $f = 300\,\mathrm{Hz}$.

Solution

The current and voltage are in phase once there is only a pure ohmic (= pure real) resulting impedance $\underline{Z} = \underline{X}_1$.

Therefore, the component must be a capacitor with the same absolute value of impedance, $|\underline{X}_C| = |\underline{X}_1|$.

Thereby, the value of the capacitance can be calculated as

$$\begin{aligned} \underline{I} &= {{\underline{U}}\over{\underline{Z}}} \\ &= {{50 ~\mathrm{V}}\over{ 0.24 ~\Omega + {\rm j} \cdot 4.68 ~\Omega }} \\ &= {{50 ~\mathrm{V}}\over{ 0.24 ~\Omega + {\rm j} \cdot 4.68 ~\Omega }} \cdot {{ 0.24 ~\Omega - {\rm j} \cdot 4.68 ~\Omega }\over{ 0.24 ~\Omega - {\rm j} \cdot 4.68 ~\Omega }} \\ &= {{2}\over{3-4{\rm j}}} \cdot (3-4{\rm j}) \\ &= \left({{2}\over{9+16}} \cdot (3-4{\rm j}) \right) \cdot (3-4{\rm j}) \\ &= \left({{2}\over{25}} \cdot (3-4{\rm j}) \right) \cdot (3-4{\rm j}) \\ &= {{2}\over{25}} \cdot (3-4{\rm j}) \cdot (3-4{\rm j}) \\ &= {{2}\over{25}} \cdot (9-24{\rm j}-16) \\ &= {{2}\over{25}} \cdot (-7-24{\rm j}) \\ &= -{{14}\over{25}} - {{48}\over{25}}{\rm j} \end{aligned}$$

With the complex part comes the physical value

$$\begin{aligned} X_L &= {{\mathrm{Im}(\underline{Z})}\over{2\pi \cdot f}} \\ &= {{4.68 ~\Omega}\over{2\pi \cdot 300 ~\mathrm{Hz}}} \\ &= {{4.68 ~\Omega}\over{1884.96 ~\mathrm{Hz}}} \\ &= 2.48 ~\mathrm{mH} \end{aligned}$$

The phase φ_i can be calculated as

$$\begin{aligned} \varphi_i &= \arctan \left({{\mathrm{Im}()}\over{\mathrm{Re}()}} \right) \\ &= \arctan \left({{-4.68 ~\Omega}\over{0.24 ~\Omega}} \right) \\ &= -87.06^\circ \end{aligned}$$