task_uzbbnoz8abe6201d_with_calculation

Student Group

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exam ee1 SS2023

Exercise E3 Impedances at Frequencies
(written test, approx. 14 % of a 60-minute written test, SS2023)

At which frequency f_2 do the following impedances have the same value?
1. An inductor with $X_{L1} = 60 ~\rm m\Omega$ and $L_1 = 15.9 ~\rm \mu H$.

Solution
Solution

\begin{align*} f_2 &= 3.8 ~\rm MHz \\ \Rightarrow f_2 &= 4.0 ~\rm MHz \end{align*}

\begin{align*} X_{L2} &= X_{C2} \\ \omega_2 \cdot L_2 &= \frac{1}{\omega_2 \cdot C_2} \\ 2\pi f_2 \cdot L_2 &= \frac{1}{2\pi f_2 \cdot C_2} \\ f_2^2 &= \frac{1}{(2\pi)^2 \cdot L_2 \cdot C_2} \\ \Rightarrow f_2 &= \frac{1}{2\pi \sqrt{L_2 \cdot C_2}} \end{align*}

\begin{align*} X_{L1} &= \omega_1 \cdot L_1 = 2\pi f_1 \cdot L_1 \\ &= 2\pi \cdot 4.0 ~\rm MHz \cdot 1.6 ~\rm \mu H \\ &= 2\pi \cdot 4.0 \cdot 10^6 ~\rm \frac{1}{s} \cdot 1.6 \cdot 10^{-6} ~\rm \frac{Vs}{A} \\ &= 40 ~\rm \Omega \end{align*}

\begin{align*} X_{C2} &= \frac{1}{\omega_2 \cdot C_2} = \frac{1}{2\pi f_2 \cdot C_2} \\ C_2 &= \frac{1}{2\pi f_2 \cdot X_{C2}} = \frac{1}{2\pi \cdot 4.0 \cdot 10^6 ~\rm \frac{1}{s} \cdot 40 ~\rm \Omega} \\ &= \frac{1}{2\pi \cdot 4.0 \cdot 10^6 \cdot 40 ~\rm \frac{As}{V}} \\ &= 1 ~\rm nF \end{align*}

\begin{align*} L_2 &= \frac{1}{(2\pi f_2)^2 \cdot C_2} = \frac{1}{(2\pi \cdot 4.0 \cdot 10^6 ~\rm \frac{1}{s})^2 \cdot 1 ~\rm nF} \\ &= \frac{1}{(2\pi)^2 \cdot 16 \cdot 10^{12} ~\rm \frac{1}{s^2} \cdot 1 \cdot 10^{-9} ~\rm \frac{As}{V}} \\ &= \frac{1}{(2\pi)^2 \cdot 16 \cdot 10^3 ~\rm \frac{1}{A/Vs}} \\ &= \frac{1}{(2\pi)^2 \cdot 16 \cdot 10^3} ~\rm \frac{Vs}{A} \\ &= 1.6 ~\rm \mu H \end{align*}