

# task\_yh4srwxu1bo1rdy4\_with\_calculation

## Student Group

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### Exercise E5 Magnetic Circuit

(written test, approx. 10 % of a 120-minute written test, SS2024)

2. Redo the calculation for the impedance  $Z_{RLC}$  for the given circuit with an AC voltage source  $U_C = 100 \text{ V}$  and a real capacitor  $C = 10 \text{ nF}$ . What is the equivalent series inductance  $L$  in the shown circuit?

Path

$U_C = 100 \text{ V}$

- $f_{\text{res}} = 83.7 \text{ kHz}$
- $|Z_{RLC}(f_r)| = 100 \text{ m}\Omega$

The formula for the resonance frequency  $f_r$  is:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

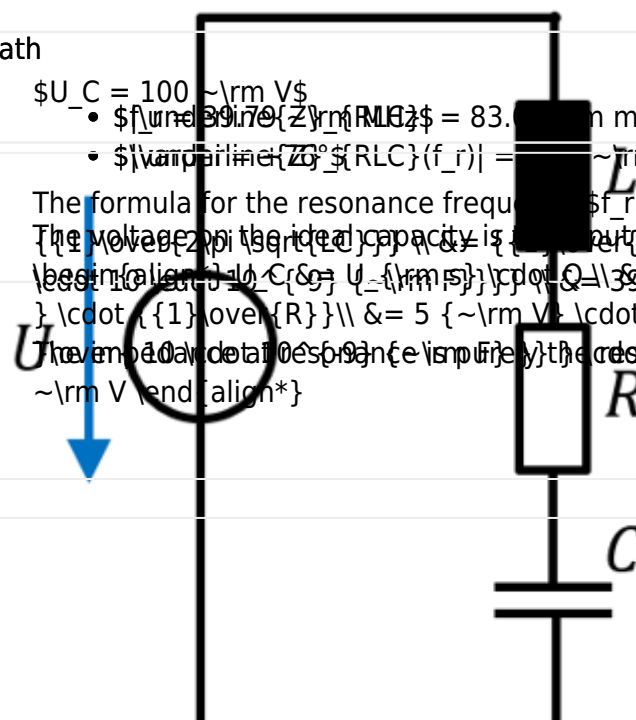
The voltage on the ideal capacitor is  $U_C = 100 \text{ V}$ . The voltage on the real capacitor is  $U_R = 5 \text{ V}$ .

The impedance of the real capacitor is  $Z_C = \frac{1}{j\omega C} = -j9.9 \text{ m}\Omega$ .

The impedance of the real inductor is  $Z_L = j\omega L = j100 \text{ m}\Omega$ .

The impedance of the real resistor is  $Z_R = R = 100 \text{ m}\Omega$ .

The total impedance is  $Z_{RLC} = Z_L + Z_R + Z_C = j100 \text{ m}\Omega + 100 \text{ m}\Omega - j9.9 \text{ m}\Omega = 100 \text{ m}\Omega + j90.1 \text{ m}\Omega$ .



A given capacitor shall have the following values:

- $C = 10 \text{ nF}$
- $R = 20 \text{ m}\Omega$
- $L = 1.6 \text{ nH}$

1. What is the impedance  $Z_{RLC}$  of this real capacitor for  $f_0 = 44 \text{ MHz}$ ? (Phase and magnitude)

Path

The impedance is based on the resistance  $R$  and the reactance  $X_{LC}$ :

$$\underline{Z}_{RLC} = R + j(X_L - X_C) = R + j(\omega L - \frac{1}{\omega C}) = R + j(2\pi f L - \frac{1}{2\pi f C})$$

The reactive part is

$$X_{LC} = 2\pi f L - \frac{1}{2\pi f C}$$

$$C\}} \\\ &= 2\pi \cdot 44 \cdot 10^6 \cdot \{ \sim \text{MHz} \} \cdot 1.6 \cdot 10^{-9} \cdot \{ \sim \text{H} \} - \\ &\{ \frac{1}{2\pi \cdot 10^6 \cdot \{ \sim \text{MHz} \} \cdot 10 \cdot 10^{-9} \cdot \{ \sim \text{F} \}} \} \\\ &+ 0.08062... \cdot \Omega \\\ \end{align*}$$

To get the magnitude of the impedance  $|\underline{Z}_{\text{RLC}}|$  one can use the Pythagorean Theorem: 
$$|\underline{Z}_{\text{RLC}}| = \sqrt{R^2 + X_{\text{LC}}^2} \\\ &= \sqrt{(0.020 \cdot \Omega)^2 + (0.08062... \cdot \Omega)^2} \\\ &= 0.0830... \cdot \Omega \\\ \end{align*}$$

For the phase  $\varphi$  the  $\arctan$  can be applied: 
$$\varphi = \arctan \left( \frac{X_{\text{LC}}}{R} \right) \\\ &= \arctan \left( \frac{0.08062... \cdot \Omega}{0.020 \cdot \Omega} \right) \\\ &= 1.3276... \hat{=} +76^\circ \\\ \end{align*}$$

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