

# task\_yh4srwxu1bo1rdy4\_with\_calculation

## Student Group

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resonance, impedance, resonant circuit, exam ee2 SS2024

**Exercise E18 Magnetic Circuit**

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

2. For a series RLC circuit with a voltage source  $U_C = 100 \text{ V}$ , a resistor  $R = 5 \text{ }\Omega$ , an inductor  $L = 1.6 \text{ nH}$  and a capacitor  $C = 10 \text{ nF}$ . What is the resonance frequency  $f_r$  and the impedance  $Z_{RLC}$  at this frequency?

Path

- $U_C = 100 \text{ V}$
- $f_r = 99.7 \text{ MHz}$
- $Z_{RLC}(f_r) = 83.9 \text{ m}\Omega$

The formula for the resonance frequency  $f_r$  is:

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

The voltage across the ideal capacitor is:

$$U_C = U \cdot Q = U \cdot \frac{\omega L}{R} = 100 \text{ V} \cdot \frac{2\pi \cdot 99.7 \cdot 10^6 \text{ s}^{-1} \cdot 1.6 \cdot 10^{-9} \text{ H}}{5 \text{ }\Omega} = 200 \text{ V}$$

The impedance at resonance is:

$$Z_{RLC}(f_r) = R = 5 \text{ }\Omega$$

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  $X_{LC} = j(X_L - X_C)$ :

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

The reactive part is:

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

$$C) \quad \omega = 2\pi \cdot 44 \cdot 10^6 \text{ MHz} \cdot 1.6 \cdot 10^{-9} \text{ H} - \frac{1}{2\pi \cdot 10^6 \text{ MHz} \cdot 10 \cdot 10^{-9} \text{ F}} \quad \omega = +0.08062... \omega$$

To get the magnitude of the impedance  $|Z_{RLC}|$  one can use the Pythagorean Theorem: 
$$|Z_{RLC}| = \sqrt{R^2 + X_{LC}^2} = \sqrt{(0.020 \omega)^2 + (0.08062... \omega)^2} = 0.0830... \omega$$

For the phase  $\varphi$  the  $\arctan$  can be applied: 
$$\varphi = \arctan\left(\frac{X_{LC}}{R}\right) = \arctan\left(\frac{0.08062... \omega}{0.020 \omega}\right) = 1.3276... \hat{=} +76^\circ$$

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