

# task\_7el8zljglaazxtw\_with\_calculation

## Student Group

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## resonant circuit, exam ee2 SS2022

**Exercise E13 Series Resonant Circuit****(written test, approx. 10 % of a 120-minute written test, SS2022)**

2. What is the resonance frequency of the circuit shown in the figure? The circuit consists of an AC voltage source  $U$  with an effective value  $U_0 = 100 \text{ V}$ , a resistor  $R = 150 \text{ }\Omega$ , an inductor  $L = 60 \text{ }\mu\text{H}$ , and a capacitor  $C = 10 \text{ nF}$ .

At resonance, the impedance of the circuit is purely real and its magnitude is  $Z_0 = R$ . Which value would  $C_0$  have for the given  $f_0$ ?

Path:  $C = 10 \text{ nF}$

$$R = 150 \text{ }\Omega$$

Path:  $Z_0 = R = 150 \text{ }\Omega$

$$Z_0 = R = 150 \text{ }\Omega$$

The resonance frequency is given as  $f_0 = \frac{1}{2\pi\sqrt{LC}}$

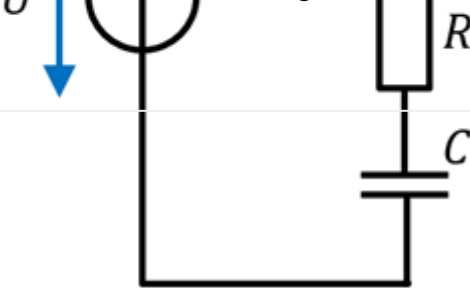
$$\Rightarrow C = \frac{1}{4\pi^2 f_0^2 L} = \frac{1}{4\pi^2 (100 \text{ MHz})^2 \cdot 60 \cdot 10^{-6} \text{ H}} = 10.6 \text{ nF}$$

What is the impedance  $Z_{RLC}$  of this real capacitor for  $f_0 = 100 \text{ MHz}$ ? (Phase and magnitude)

$$Z_{RLC} = R + j\omega L - \frac{j}{\omega C} = 150 \text{ }\Omega + j\omega L - \frac{j}{\omega C}$$

At resonance, the impedance is purely real and its magnitude is  $Z_0 = R$ .

$$\text{With values: } C = \frac{1}{4\pi^2 f_0^2 L} = \frac{1}{4\pi^2 (100 \text{ MHz})^2 \cdot 60 \cdot 10^{-6} \text{ H}} = 10.6 \text{ nF}$$



1. What is the impedance  $\underline{Z}_{RLC}$  of this real capacitor for  $f_0 = 100 \text{ MHz}$ ? (Phase and magnitude)

Path

The impedance  $\underline{Z}_{RLC}$  is given by:  $\underline{Z}_{RLC} = R + j\omega L - \frac{j}{\omega C}$

$$\underline{Z}_{RLC} = R + j\omega L - \frac{j}{\omega C} = R + j\omega L - \frac{j}{\omega C}$$

Putting in the numbers, only for the reactive part  $X_{LC}$ :  $X_{LC} = \omega L - \frac{1}{\omega C}$

$$X_{LC} = 2\pi \cdot 100 \text{ MHz} \cdot 60 \cdot 10^{-6} \text{ H} - \frac{1}{2\pi \cdot 100 \text{ MHz} \cdot 10.6 \cdot 10^{-9} \text{ F}} = -121.45 \text{ m}\Omega$$

With the real and imaginary parts, we can derive the magnitude and phase:

$$\begin{aligned} Z_{\text{RLC}} &= \sqrt{R^2 + \{X\}_{\text{LC}}^2} \quad \&= \sqrt{(88 \sim \text{m}\Omega)^2 + (-121.45 \sim \text{m}\Omega)^2} \quad \&= 150.0... \sim \text{m}\Omega \\ \end{aligned}$$

$$\begin{aligned} \varphi &= \arctan \left( \frac{\{X\}_{\text{LC}}}{R} \right) \quad \&= \arctan \left( \frac{-121.45 \sim \text{m}\Omega}{88 \sim \text{m}\Omega} \right) \quad \&= -0.9437... \\ &= -54.07...^\circ \quad \end{aligned}$$

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