

task_7el8zljglaazxtw_with_calculation

Student Group

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resonant circuit, exam ee2 SS2022

Exercise E14 Series Resonant Circuit
(written test, approx. 10 % of a 120-minute written test, SS2022)

2. What is the resonance frequency of a series RLC circuit with an inductor of inductance L and a capacitor of capacitance C in series with a resistor of resistance R ?

At this resonance frequency, the total impedance of the circuit would be $X_{C0} = Z_{RLC}$. Which value would C_0 have for the given f_0 ?

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

$R = 88.6 \text{ m}\Omega$

Path: $L = 60 \text{ pH}$

$Z_{RLC} = 255.5 \text{ M}\Omega$

$X_{C0} = 88.6 \text{ m}\Omega$

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

What is the total impedance of the circuit at resonance? $Z_{RLC} = 255.5 \text{ M}\Omega$

$Z_{RLC} = R + j\omega L - \frac{j}{\omega C} \rightarrow C$

At resonance, the impedance is given purely by the resistor.

With values: $C = \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 10.6 \cdot 10^{-9}}$

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

Path

The impedance Z_{RLC} is given by:

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

Putting in the numbers, only for the reactive part X_{LC} :

$$X_{LC} = 2\pi \cdot 100 \cdot 10^6 \cdot 60 \cdot 10^{-12} - \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 10 \cdot 10^{-9}}$$

$$X_{LC} = -121.45 \text{ m}\Omega$$

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

$$Z_{RLC} = \sqrt{R^2 + X_{LC}^2} = \sqrt{(88 \text{ m}\Omega)^2 + (-121.45 \text{ m}\Omega)^2} = 150.0... \text{ m}\Omega$$
$$\varphi = \arctan\left(\frac{X_{LC}}{R}\right) = \arctan\left(\frac{-121.45 \text{ m}\Omega}{88 \text{ m}\Omega}\right) = -0.9437... = -54.07...^\circ$$

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