

task_7el8zljglaazxtw_with_calculation

Student Group

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resonant circuit, exam ee2 SS2022

Exercise E10 Series Resonant Circuit
(written test, approx. 10 % of a 120-minute written test, SS2022)

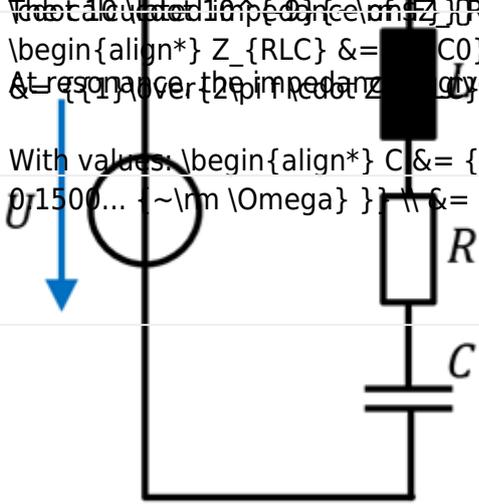
2. What is the resonance frequency of a series RLC circuit with an inductor of inductance L and a capacitor of capacitance C in series? The resonance frequency is the frequency at which the total impedance is purely resistive.

At this frequency, the total impedance of the circuit is Z_{RLC} . Which value would C have for the given f_0 ?

- Path: $C = 10 \text{ nF}$
- $R = 100 \text{ } \Omega$
 - $Z_{RLC} = 250.5 \text{ } \Omega$
 - $L = 60 \text{ } \mu\text{H}$
 - $f_0 = 100 \text{ MHz}$

The resonance frequency is given as $f_0 = \frac{1}{2\pi\sqrt{LC}}$.
 That is, $\frac{1}{2\pi\sqrt{LC}} = 100 \text{ MHz}$.
 The total impedance of the circuit is $Z_{RLC} = R + j\omega L - \frac{j}{\omega C}$.
 At resonance, the impedance is purely resistive.

With values: $C = \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 60 \cdot 10^{-9}} = 10.6 \text{ nF}$



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

Putting in the numbers, only for the reactive part X_{LC} :
 $X_{LC} = 2\pi \cdot 100 \cdot 10^6 \cdot 60 \cdot 10^{-9} - \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 10.6 \cdot 10^{-9}}$
 $X_{LC} = 2\pi \cdot 100 \cdot 10^6 \cdot 60 \cdot 10^{-9} - \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 10.6 \cdot 10^{-9}}$
 $X_{LC} = -121.45 \text{ m}\Omega$

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

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

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