

task_nyniewamxfshpuwt_with_calculation

Student Group

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resonance, resonant circuit, RMS, exam ee2 SS2021

Exercise E24 Resonant Circuit
(written test, approx. 4 % of a 120-minute written test, SS2021)

6) You have a generalistic RLC circuit that is fed by a sine wave of the voltage $u(t) = U_{\text{rms}} \cdot \sin(2\pi \cdot f_0 \cdot t)$. The capacitance C and the inductance L are fixed. The resistance R can be varied.

- $U_{\text{rms}} = 12 \text{ V} \cdot \sin(2\pi \cdot f_0 \cdot t)$

Path: $R_i = 200 \text{ m}\Omega$

- $R = 205.5 \text{ m}\Omega$

- $C = 30 \text{ nF}$

For the following calculation, the internal resistance R_i and the resistance R have to be combined: $R_{\Sigma} = R_i + R$

Here, either one knows that the gain factor Q stands for $Q = \frac{U_C}{U_{\text{rms}}}$ and therefore can directly use the following formula: $Q = \frac{U_C}{U_{\text{rms}}} = \frac{1}{R_{\Sigma}} \sqrt{\frac{L}{C}}$
 $R_{\Sigma} = \frac{U_{\text{rms}}}{U_C} \sqrt{\frac{L}{C}}$

When the gain factor is not known, one has to derive it:

The voltage I at resonance is only given by the total ohmic resistance R_{Σ} and the source voltage U_{rms} : $I = \frac{U_{\text{rms}}}{R_{\Sigma}}$

This current flow also through the impedance of the capacitor $Z_C = \frac{1}{\omega C}$
 $U_C = Z_C \cdot I = \frac{1}{\omega C} \cdot \frac{U_{\text{rms}}}{R_{\Sigma}}$

At resonance, the angular frequency ω is given by $\omega = \frac{1}{\sqrt{LC}}$

$$U_C = \frac{U_{\text{rms}}}{\frac{1}{\sqrt{LC}} \cdot R_{\Sigma}} = \frac{U_{\text{rms}} \cdot \sqrt{LC}}{R_{\Sigma}}$$

a) What is the resonance frequency f_0 ?

Path

In both cases, we end up with the same formula, where we have to insert the physical values: $R_{\Sigma} = \frac{U_{\text{rms}}}{U_C} \sqrt{\frac{L}{C}}$
 $R_{\Sigma} = \frac{1}{4} \sqrt{\frac{20 \cdot 10^{-3} \text{ H}}{30 \cdot 10^{-6} \text{ F}}}$

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

And so, the resistance R is: $R = R_{\Sigma} - R_i$

$$R = \frac{1}{4} \sqrt{\frac{20 \cdot 10^{-3} \text{ H}}{30 \cdot 10^{-6} \text{ F}}} - 200 \text{ m}\Omega = 205.4681 \text{ m}\Omega$$

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