

task_nyniewamxfshpuwt_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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resonance, resonant circuit, RMS, exam ee2 SS2021

Exercise E1 Resonant Circuit
(written test, approx. 4 % of a 120-minute written test, SS2021)

6) An alternating current source with the effective voltage U_{eff} (r.m.s. value) is connected in series with a capacitor C and a resistor R . The resistance R can be varied. The capacitance C and the angular frequency ω are fixed. The resistance R is independent of ω .

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

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 $Q = \frac{U_C}{U_{\text{eff}}}$ and therefore can directly use the following formula: $Q = \frac{U_C}{U_{\text{eff}}} = \frac{1}{R_{\Sigma}} \sqrt{\frac{L}{C}}$
 $R_{\Sigma} = \frac{U_{\text{eff}}}{U_C} \sqrt{\frac{L}{C}}$

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_{eff} : $I = \frac{U_{\text{eff}}}{R_{\Sigma}}$

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

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

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

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: $R_{\Sigma} = \frac{U_{\text{eff}}}{U_C} \sqrt{\frac{L}{C}} = \frac{1}{4} \sqrt{\frac{20 \cdot 10^{-3} \text{ H}}{30 \cdot 10^{-6} \text{ F}}}$

The resonant frequency f_0 is given as $f_0 = \frac{1}{2\pi \sqrt{LC}} = 6.25 \text{ kHz}$

And so, the resistance R is: $R = R_{\Sigma} - R_i = 205.5 \text{ m}\Omega - 200 \text{ m}\Omega = 5.5 \text{ m}\Omega$

$$f_0 = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{2\pi \sqrt{20 \cdot 10^{-3} \text{ H} \cdot 30 \cdot 10^{-6} \text{ F}}} = 6.25 \text{ kHz}$$

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