

# task\_pdkggtyexxy1ktu3\_with\_calculation

## Student Group

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## complex impedance, exam ee1 WS2022

**Exercise 1.1 : Impedances at Frequencies**

(written test, approx. 18 % of a 60-minute written test, WS2022)

Calculate the **resistor values** which have to be used in the following circuits.

1. A resistor  $R_1$  shall have the same absolute value of the impedance as a capacitor  $C_1=40 \text{ nF}$  at  $f_1=4 \text{ MHz}$ .

Solution

$$\begin{aligned} R_1 &= |\underline{X}_{C1}| = \frac{1}{2\pi \cdot f \cdot C_1} \\ &= \frac{1}{2\pi \cdot 4 \text{ MHz} \cdot 40 \text{ nF}} \end{aligned}$$

Final result

$$R_1 = 1.00 \text{ } \Omega$$

2. A  $RL$  series circuit with  $L_2=4.7 \text{ } \mu\text{H}$ , where an AC voltage source of  $U_2=1.0 \text{ V}$  with  $f_2=450 \text{ kHz}$  generates a current  $I_2=60 \text{ mA}$ .

Solution

Series circuit means that the current is constant on every component.

The equivalent impedance for  $R$  and  $L$  combined is given by 
$$\frac{\underline{U}}{\underline{I}} = R_2 + \underline{X}_{L2} = R_2 + j \cdot \omega L$$
 Since  $j \cdot \omega L$  is perpendicular to  $R_2$  this can be simplified to: 
$$\left| \frac{\underline{U}}{\underline{I}} \right|^2 = |R_2|^2 + |\underline{X}_{L2}|^2 \iff \left( \frac{U}{I} \right)^2 = R_2^2 + X_{L2}^2$$

This can be rearranged to get  $R_2$ : 
$$R_2 = \sqrt{\left( \frac{U}{I} \right)^2 - X_{L2}^2} = \sqrt{\left( \frac{1 \text{ V}}{60 \text{ mA}} \right)^2 - (2\pi \cdot 450 \text{ kHz} \cdot 4.7 \text{ } \mu\text{H})^2}$$

## Final result

$$\begin{aligned} R_2 &= 10.0 \, \Omega \end{aligned}$$

3. A RC parallel circuit with  $C_3 = 4.7 \, \text{nF}$  on an AC current source ( $I_{3S} = 1.3 \, \text{mA}$ ,  $f_3 = 200 \, \text{kHz}$ ), which generates a current of  $I_{3R} = 1.0 \, \text{mA}$  through  $R_3$ .

## Solution

Parallel circuit means that the voltage is the same on  $R_3$  and  $C_3$ :

$$\underline{U}_3 = R_3 \cdot \underline{I}_{3R} = -j \cdot X_{3C} \cdot \underline{I}_{3C}$$
 So it gets clear, that  $\underline{I}_{3R}$  is perpendicular to  $\underline{I}_{3C}$  (It has to, since  $R_3$  is perpendicular to  $-j \cdot X_{3C}$ , too).

Therefore, the resulting current of the parallel circuit is given as:

$$\begin{aligned} \underline{I}_3 &= \underline{I}_{3R} + \underline{I}_{3C} \\ |\underline{I}_3|^2 &= |\underline{I}_{3R}|^2 + |\underline{I}_{3C}|^2 \\ \underline{I}_3 &= \sqrt{|\underline{I}_{3R}|^2 + |\underline{I}_{3C}|^2} \end{aligned}$$

Back in the first formula:

$$\begin{aligned} R_3 \cdot \underline{I}_{3R} &= X_{3C} \cdot \underline{I}_{3C} \\ R_3 &= X_{3C} \cdot \frac{|\underline{I}_{3C}|}{|\underline{I}_{3R}|} \\ &= \frac{1}{2\pi \cdot f \cdot C_3} \cdot \frac{\sqrt{|\underline{I}_3|^2 - |\underline{I}_{3R}|^2}}{|\underline{I}_{3R}|} \end{aligned}$$

## Final result

$$\begin{aligned} R_3 &= 70.0 \, \Omega \end{aligned}$$

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