

# task\_wjttvmydrskzhcim\_with\_calculation

## Student Group

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complex voltage divider, RMS, inductor, exam ee2 SS2021

**Exercise E9 Component Parameters**  
**(written test, approx. 10 % of a 120-minute written test, SS2021)**

Determine the component parameters of a motor (motor M) presents a resistive inductive load! For the next exercises consider the following RMS values of the series resistance  $R_{\text{M}}$  and the inductance  $L_{\text{M}}$  are to be determined below. Both results in the impedance of the motor. But two different frequencies,  $f_1$  and  $f_2$  was applied.

This resulted in the recorded current of  
 a) Derive in general the equation for the absolute value of the impedance of the motor.

$$|Z| = \sqrt{(2\pi \cdot f \cdot L_{\text{M}})^2 + R_{\text{M}}^2}$$

- $R_{\text{M}} = 10 \cdot \Omega$
- $L_{\text{M}} = 10 \cdot \text{mH}$

b) Since we have the absolute values of the impedances from the specified formulas from a) and this has the advantage that  $R_{\text{M}}$  will cancel out:

$$Z_2^2 - Z_1^2 = (2\pi \cdot f_2 \cdot L_{\text{M}})^2 + R_{\text{M}}^2 - \left( (2\pi \cdot f_1 \cdot L_{\text{M}})^2 + R_{\text{M}}^2 \right)$$

The complex impedance  $\underline{Z}$  for a resistive inductive load  $R_{\text{M}}$  and  $L_{\text{M}}$  in series circuit is given as

$$\underline{Z} = R_{\text{M}} + j \cdot X_{L_{\text{M}}} = R_{\text{M}} + j \cdot 2\pi \cdot f \cdot L_{\text{M}}$$

Now we can rearrange to  $L_{\text{M}}$ :

$$\begin{aligned} |Z_2|^2 - |Z_1|^2 &= (2\pi \cdot f_2 \cdot L_{\text{M}})^2 + R_{\text{M}}^2 - \left( (2\pi \cdot f_1 \cdot L_{\text{M}})^2 + R_{\text{M}}^2 \right) \\ &= (2\pi \cdot f_2 \cdot L_{\text{M}})^2 - (2\pi \cdot f_1 \cdot L_{\text{M}})^2 \\ &= L_{\text{M}}^2 \cdot (2\pi)^2 \cdot (f_2^2 - f_1^2) \\ &= L_{\text{M}}^2 \cdot (2\pi)^2 \cdot (f_2 - f_1) \cdot (f_2 + f_1) \end{aligned}$$

And then to  $L_{\text{M}}$ :

$$L_{\text{M}} = \frac{1}{2\pi} \sqrt{\frac{Z_2^2 - Z_1^2}{f_2^2 - f_1^2}}$$

With the values:

$$L_{\text{M}} = \frac{1}{2\pi} \sqrt{\frac{(10 \cdot \Omega)^2 - (6.25 \cdot \Omega)^2}{(100 \cdot \text{s}^{-1})^2 - (50 \cdot \text{s}^{-1})^2}} = 14.346 \cdot \text{mH}$$

The resistance value  $R_{\text{M}}$  can be derived from

$$Z_2^2 = (2\pi \cdot f_2 \cdot L_{\text{M}})^2 + R_{\text{M}}^2 \implies R_{\text{M}}^2 = Z_2^2 - (2\pi \cdot f_2 \cdot L_{\text{M}})^2$$

$$R_{\text{M}} = \sqrt{(10 \cdot \Omega)^2 - (2\pi \cdot 100 \cdot \text{s}^{-1} \cdot 0.014346 \cdot \text{H})^2} = 4.3301 \cdot \Omega$$

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