

task_wjttvmydrskzhcim_with_calculation

Student Group

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complex voltage divider, RMS, inductor, exam ee2 SS2021

Exercise E1 Component Parameters
(written test, approx. 10 % of a 120-minute written test, SS2021)

Determine the complex impedance of a motor (motor M) presents a resistive inductive load! For the next exercises consider the following RMS values of the series resistance R_{M} and the inductance L_{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.

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

$$R_{\text{M}} = 4 \cdot \Omega$$

b) Since we have the absolute values of the impedances from the specified formulas from a) and this has the advantage that R_{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_{M} and L_{M} in series circuit is given as

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

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

Now we can rearrange to L_{M} :

The Pythagorean theorem can derive the absolute value:

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

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

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

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

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

And then to R_{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:

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

The resistance value R_{M} can be derived from $Z_2^2 = (2\pi \cdot f_2 \cdot L_{\text{M}})^2 + R_{\text{M}}^2$

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

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