

task_rdz03rspbwusy7wk_with_calculation

Student Group

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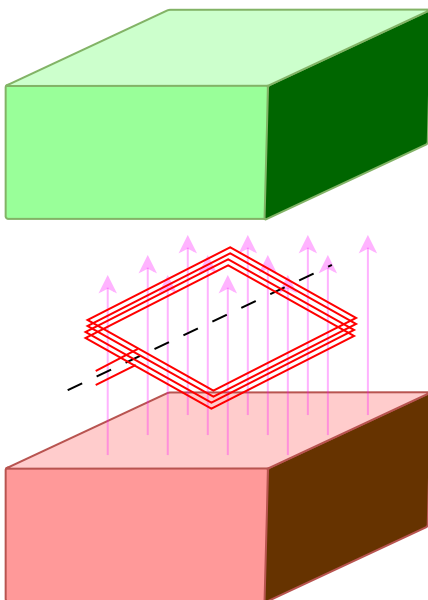
Exercise E7 Coil in a magnetic Field (written test, approx. 4 % of a 120-minute written test, SS2021)

A coil with $n = 300$ turns and a cross-sectional area $A = 600 \text{ cm}^2$ is located in a homogeneous magnetic field.

The rotation of the coil causes a sinusoidal change in the magnetic field in the coil with the frequency $f = 80 \text{ Hz}$.

The maximum value of the magnetic flux density in the coil is $\hat{B} = 2 \cdot 10^{-6} \text{ Vs/cm}^2$.

$$u_{\text{ind}} = -181 \text{ V} \cdot \cos(503 \text{ s}^{-1} \cdot t)$$



Derive the formula for the voltage induced in the coil and calculate the voltage amplitude.

Path

The induced voltage u_{ind} is given by:

$$u_{\text{ind}} = - \frac{d\Psi(t)}{dt} = - n \frac{d\Phi(t)}{dt}$$

With $\Phi(t) = B(t) \cdot A$, where A is the constant area of a single winding and $B(t)$ is the changing field through this winding.

Due to the rotation, the field changes as:

$$B(t) = \hat{B} \cdot \sin(\omega t + \varphi) = \hat{B} \cdot \sin(2\pi f \cdot t + \varphi)$$

This leads to:
$$u_{\text{ind}} = - n \frac{d}{dt} A \hat{B} \cdot \sin(2\pi f \cdot t + \varphi) \quad \&= - n \cdot A \hat{B} \cdot 2\pi f \cdot \cos(2\pi f \cdot t + \varphi)$$

The absolute value of the factor in front of the $\cos$ is the maximum induced voltage $\hat{U}_{\text{ind}}$:
$$\hat{U}_{\text{ind}} = n \cdot A \hat{B} \cdot 2\pi f \quad \&= 300 \cdot 0.06 \text{ m}^2 \cdot 2 \cdot 10^{-2} \text{ T} \cdot 50 \frac{\text{Vs}}{\text{m}^2} \cdot 2\pi \cdot 80 \frac{1}{\text{s}} \quad \&= 180.95... \text{ V}$$

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