

task_w3m7fo4hjahlkzogl_with_calculatlon

Student Group

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Exercise E1 Toroidal Coil

(written test, approx. 5 % of a 120-minute written test, SS2021)

A magnetic field with a flux density of at least 50 mT is to be achieved in a ring-shaped coil (toroidal coil).

The coil has 60 turns, wound around soft iron with $\mu_r = 1200$.

The average field line length in the coil should be $l = 12 \text{ cm}$.

Result:

$$I = \frac{B}{\mu_0 \mu_r N} = \frac{50 \cdot 10^{-3} \text{ Vs/Am}}{1200 \cdot 4\pi \cdot 10^{-7} \text{ Vs/Am} \cdot 60} \approx 0.06 \text{ A}$$

What is the minimum current that must flow through a single winding?

Path

The magnetic field strength of a toroidal coil is given as:

$$H = \frac{N \cdot I}{l}$$

Based on the flux density the magnetic field strength can be derived by $B = \mu_0 \mu_r H$.

By this, the formula can be rearranged:

$$H = \frac{N \cdot I}{l} \quad || \quad \frac{B}{\mu_0 \mu_r} = H \quad || \quad I = \frac{B \cdot l}{\mu_0 \mu_r \cdot N}$$

$$\text{Putting in the numbers: } I = \frac{0.05 \text{ T} \cdot 0.12 \text{ m}}{4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}} \cdot 1'200 \cdot 60} = 0.6631... \frac{\text{T} \cdot \text{m}}{\frac{\text{Vs}}{\text{Am}}} = 0.6631... \frac{\text{Vs}}{\text{m}^2} \cdot \text{m} \cdot \frac{\text{Am}}{\text{Vs}} = 0.6631... \text{ A}$$

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