task_n1kwu944m7jac3tf_with_calculation

Student Group

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magnetic circuit, exam ee2 SS2024

Exercise E3 Magnetic Circuit
(written test, approx. 9 % of a 120-minute written test, SS2024)

A toroidal core (ferrite, $\mu_{\rm r}=900$) has a cross-sectional area of $A=300 ~\rm mm^2$ and an average circumference of $l=3 ~\rm dm$.

2. Calculate the resulting magnetic voltage $\theta_{\rm R}$ of the sources.

Result

Path

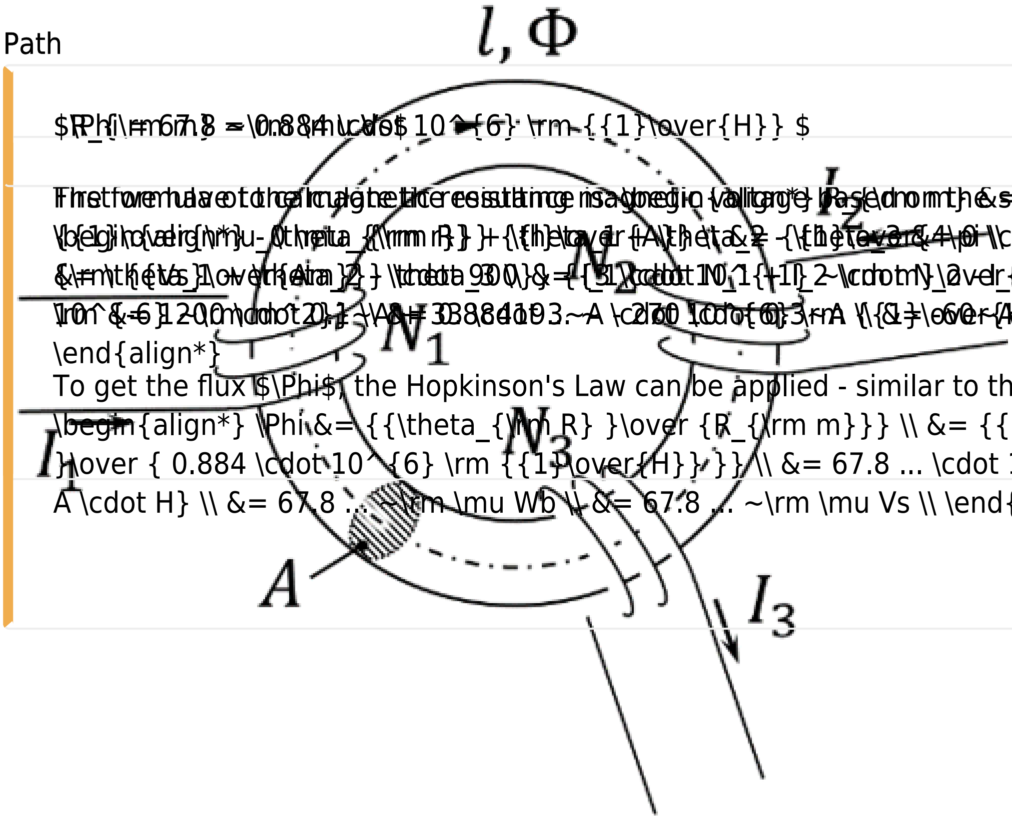
$R_{\rm m} = 0.884 \cdot 10^{6} \rm {{1}\over{H}} $

$\Phi = 67.8 ~\rm \mu Vs$

The formula of the magnetic resistance is $$\begin{align*} R_{\rm m} &= {{1}\over{\mu_0 \mu_{\rm r}}} {{l}\over{A}} \\ &= {{1}\over{4\pi \cdot 10^{-7} {\rm {Vs}\over{Am}} \cdot 900}} {{0.3 ~\rm m}\over{300 \cdot 10^{-6} ~\rm m^2}} \\ &= 0.884... \cdot 10^{6} \rm {{1}\over{H}} \end{align*}$$

First we have to calculate the resulting magnetic voltage based on the sources: $$\begin{align*} \theta_{\rm R} &= \theta_1 - \theta_2 - \theta_3 \\ &= N_1 \cdot I_1 - N_2 \cdot I_2 - N_3 \cdot I_3 \\ &= 1200 \cdot 0.1 ~\rm A - 33 \cdot 3 ~\rm A - 270 \cdot 0.3 ~\rm A \\ &= -60 ~\rm A \end{align*}$$

To get the flux Φ, the Hopkinson's Law can be applied - similar to the Ohm's Law: $$\begin{align*} \Phi &= {{\theta_{\rm R} }\over {R_{\rm m}}} \\ &= {{-60~\rm A }\over { 0.884 \cdot 10^{6} \rm {{1}\over{H}} }} \\ &= 67.8 ... \cdot 10^{-6} { \rm A \cdot H} \\ &= 67.8 ... ~\rm \mu Wb \\ &= 67.8 ... ~\rm \mu Vs \\ \end{align*}$$



On the core, there are three coils with:

- Coil 1: $N_1 = 1200$, $I_1=100 ~\rm mA$
- Coil 2: $N_2 = 33 $, $I_2= 3 ~\rm A$
- Coil 3: $N_3 = 270 $, $I_3=0.3 ~\rm A$

Refer to the drawing for the direction of the windings, current, and flux!

1. Draw the equivalent magnetic circuit that fully represents the setup.
Name all the necessary magnetic resistances, fluxes, and voltages.

Result

- Since the material, and diameter of the core is constant, one can directly simplify the magnetic resistor into a single $R_\rm m$.
- For the orientation of the magnetic voltages θ_1, θ_2, and θ_3, the orientation of the coils and the direction of the current has to be

taken into account by the right-hand rule.
- There is only one flux Φ
- The magnetic voltages are antiparallel to the flux for sources and parallel for the load.