task_unkkahm3u0v9azny_with_calculation

Student Group

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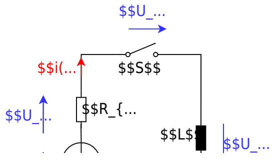
self induction, induction, exam ee2 SS2022

Exercise E1 Self Induction
(written test, approx. 8 % of a 120-minute written test, SS2022)

Actually, a motor with an inductance of $L=50 ~\rm H$ is connected to a DC voltage source, which is fused with a circuit breaker.
The circuit breaker opens at $t_0=0$ with a current of $I=63 ~\rm A$. The current is reduced linearly down to $0 ~\rm A$ within $1 ~\rm \mu s$.
(The inner resistance of the motor shall be neglected.)

1. Draw the circuit (the circuit breaker can be drawn as a switch), with all voltage and current arrows.

Result



2. What is the maximum magnitude of the voltage, which the circuit breaker has to withstand?

Path

For the maximum voltage on the circuit breaker one has to consider the following:

- external voltage of the voltage source $U_\rm s$
- voltage $u_{\rm ind} (t)$ induced by the change of the current

The first one is not given in the exercise, and therefore not considered here.

The induced voltage can be calculated by linearizing the following: \begin{align*} u_{\rm ind} (t) &= - L {{ {\rm d} i}\over{ {\rm d} t }}\\ \rightarrow u_{\rm ind} (t) &= - L {{ \Delta i}\over{ \Delta t }}\\ \end{align*}

With the given details: \begin{align*} u_{\rm ind} (t) &= - L {{ 0 - I}\over{ t_1 - t_0 }}\\ &= 50 \cdot 10^{-6} {~\rm H} {{ 63 ~\rm A}\over{ 1 \cdot 10^{-6} ~\rm s}}\\ &= 3150 {{ ~\rm Vs}\over{ ~\rm A}} \; {{ ~\rm A}\over{ ~\rm s}}\\ \end{align*}

Result

$u_{\rm ind} (t) = 3150 ~\rm V$

Sketch the diagram of $i(t)$ and $u_{\rm ind}(t)$ with the calculated value of the induced voltage.

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