Self-induction when switching on a circuit (Item No.: P1377000)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 10-13
Topic: Elektrizitätslehre
Subtopic: Elektromagnetische Induktion
Experiment: Die Selbstinduktion beim Einschaltvorgang

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

The students know that voltage is induced in a coil as long as the magnetic field inside the coil varies. They are familiar with electromagnets and, therefore, know that a coil with a current flowing through it produces a magnetic field and they know the factors responsible for the strength of the magnetic field.
This magnetic field takes time to form when the circuit is switched on and takes time to fade away when the circuit is switched off. This causes self-induced voltage to be formed each time.
In this experiment, the students should see that the self-induced voltage formed when switching on the circuit counteracts the increase in current.

Notes on setup and procedure

Since the inductance is relatively small, it may be difficult for the students to see that there is a delay between the lighting of filament lamp L1 and filament lamp L2.
Encourage them to keep trying until they perceive the delay. In the end, they may find it easier to see this by carrying out the experiment once at a low operating voltage.

Remarks

The coil functions both as a field coil and an induction coil. The voltage produced by the variation in the coil current and the resulting variation in the strength of the magnetic field in the coil is called self-induced voltage. According to Lenz's Law, this voltage always counteracts its cause.
The following equation applies:
$U_i = -L\ (dI / dt)$.
L is the self-induction coefficient or inductance. It is measured in Henry (H). The coils used in this experiment without the iron core have an inductance of 50 mH and 3 mH respectively. With a closed core, the coil with 400 turns has an inductance of 100 mH, and the coil with 1600 turns has an inductance of 700 mH.

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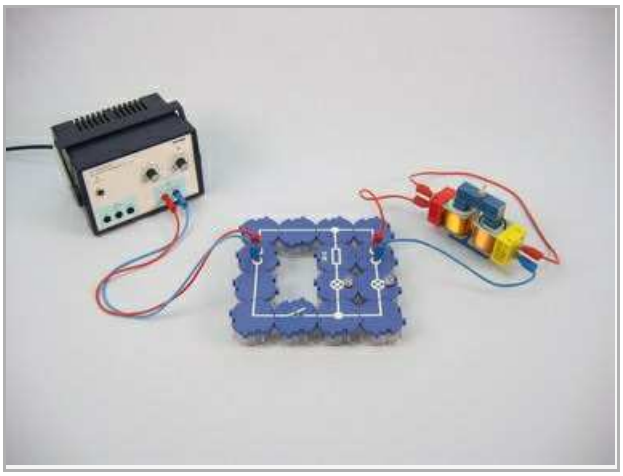
Task and equipment

Task

What effect does a coil in a direct current circuit have when the circuit is closed?

Investigate the effect of a coil installed in one of the branches in a parallel circuit of two filament lamps.



Equipment

Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	2
2	Angled connector module, SB	05601-02	4
3	T-shaped connector module, SB	05601-03	2
4	Interrupted connector module, SB	05601-04	2
5	On-off switch module, SB	05602-01	1
6	Socket module for incandescent lamp E10, SB	05604-00	2
7	Resistor module 50 Ohm, SB	05612-50	1
8	Coil, 400 turns	07829-01	1
9	Coil, 1600 turns	07830-01	1
10	U-core	07832-00	1
11	Yoke	07833-00	1
12	Tightening screw	07834-00	1
13	Connecting cord, 32 A, 250 mm, red	07360-01	2
14	Connecting cord, 32 A, 250 mm, blue	07360-04	1
15	Connecting cord, 32 A, 500 mm, red	07361-01	1
16	Connecting cord, 32 A, 500 mm, blue	07361-04	1
17	Filament lamps 4V/0.04A, E10, 10	06154-03	2 pieces
18	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

Set-up and procedure

Set-up

Place the coils on the U-core. Use the tightening screw to press the U-core and the yoke together firmly. Set up the experiment as shown in Fig. 1 and Fig. 2. The switch should be in off position.

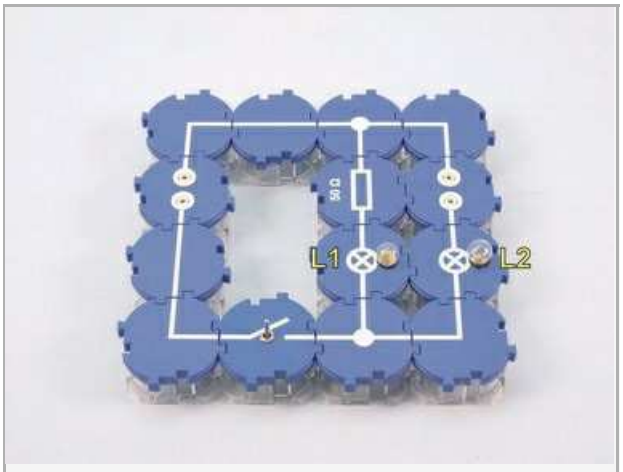


Fig. 1

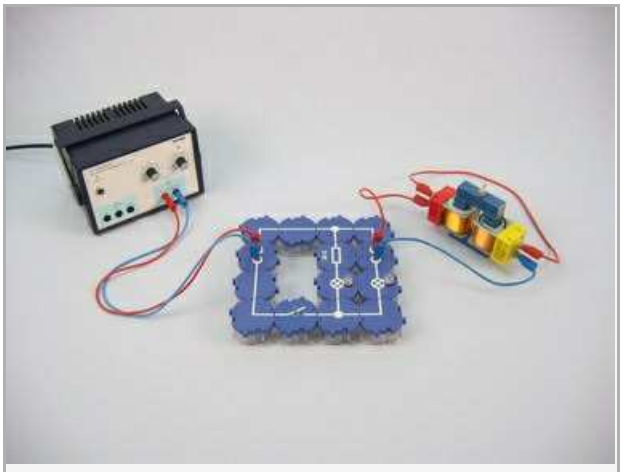


Fig. 2

Procedure

- Switch on the power supply unit and set the direct voltage to 6 V.
- Toggle the on/off switch back and forth repeatedly. While doing this, observe both filament lamps L1 and L2 simultaneously. Note your observations under Result - Observations 1 in the report.
- Unscrew the tightening screw and place the coils without the iron core next to each other as shown in Fig. 3.
- Toggle the on/off switch back and forth repeatedly. Again, observe both filament lamps simultaneously. Note your observations under Result - Observations 2.
- Switch off the power supply unit.

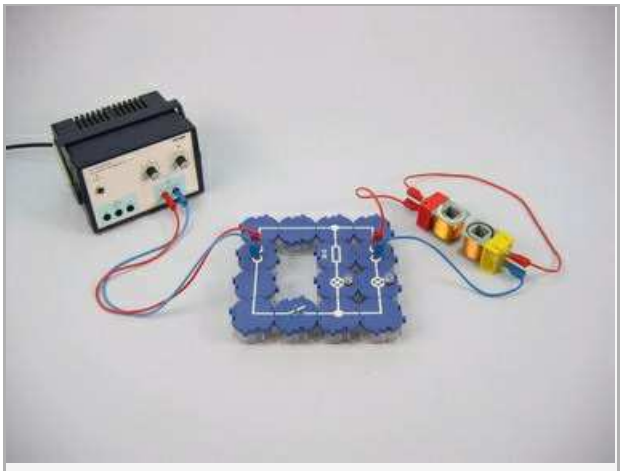


Fig. 3

Report: Self-induction when switching on a circuit

Result - Observations 1

Note your observations on

a) Circuit is closed

b) Circuit is still closed

c) Circuit is opened

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Result - Observations 2

Note your observations.

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Evaluation - Question 1

How can you explain the behaviour of the coil described under Result - Observations 1 when closing the circuit?

Note: Use your knowledge of electromagnets and electromagnetic induction in your explanation.

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Evaluation - Question 2

What role does the 50 Ω resistor play?

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Evaluation - Question 3

Why do both filament lamps go out at the same time when opening the circuit?

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Evaluation - Question 4

Why does the phenomenon observed when closing the circuit not occur when the iron cores are removed from the coils?

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