Self-induction when switching on a circuit (Item No.: P1399900)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 16-19
Topic: Electricity
Subtopic: Electromagnetic induction
Experiment: Self-induction when switching on a circuit

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

Additional Requirements:

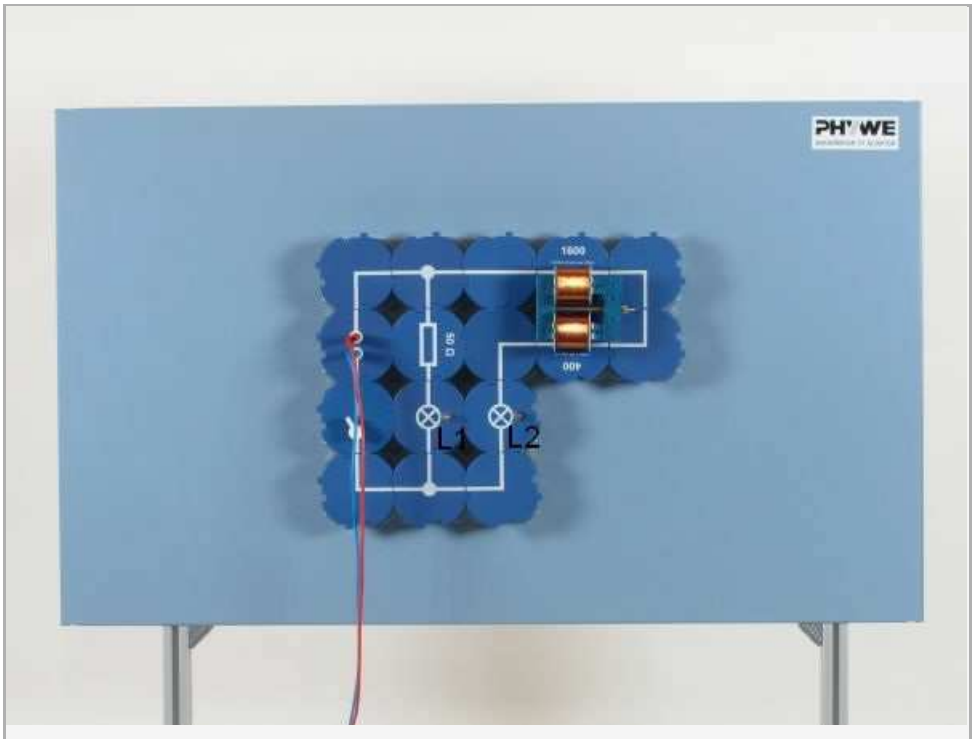
Experiment Variations:

Keywords:

Principle and equipment

Principle

A parallel connection of an ohmic resistor and a highly inductive coil is to be used to demonstrate that the coil delays the increase in the current after switching on.



Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
2	Demo Physics board with stand	02150-00	1
3	Coil 400 turns, module DB	09472-01	1
4	Coil 1600 turns, module DB	09472-02	1
5	Switch on/off, module DB	09402-01	1
6	U-core	07832-00	1
7	Socket for incandescent lamp E10 ,module DB	09404-00	2
8	Connector interrupted, module DB	09401-04	1
9	Resistor 50 Ohm,module DB	09412-50	1
10	Electr.symbols f.demo-board,12pcs	02154-03	1
11	Yoke	07833-00	1
12	Connector, straight, module DB	09401-01	1
13	Connector, angled, module DB	09401-02	6
14	Connector, T-shaped, module DB	09401-03	2
15	Filament lamps 4V/0.04A, E10, 10	06154-03	1
16	Tightening screw	07834-00	1
17	Connecting cord, 32 A, 1000 mm, red	07363-01	1
18	Connecting cord, 32 A, 1000 mm, blue	07363-04	1

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Set-up and procedure

- Set up the experiment as shown in Fig. 1; press the U-core and the yoke tightly together with the tightening screw
- With the switch first open, switch on the power supply; set a 6 V direct voltage
- Close and open the switch, and thereby concentrate on simultaneously observing the lighting up and going out of the two filament lamps L1 and L2
- Afer a short pause, close and open the switch several times and confirm your observations (1)
- Loosen the tightening screw and remove the iron core from the coil
- Again close and open the switch several times while observing L1 and L2 (2)

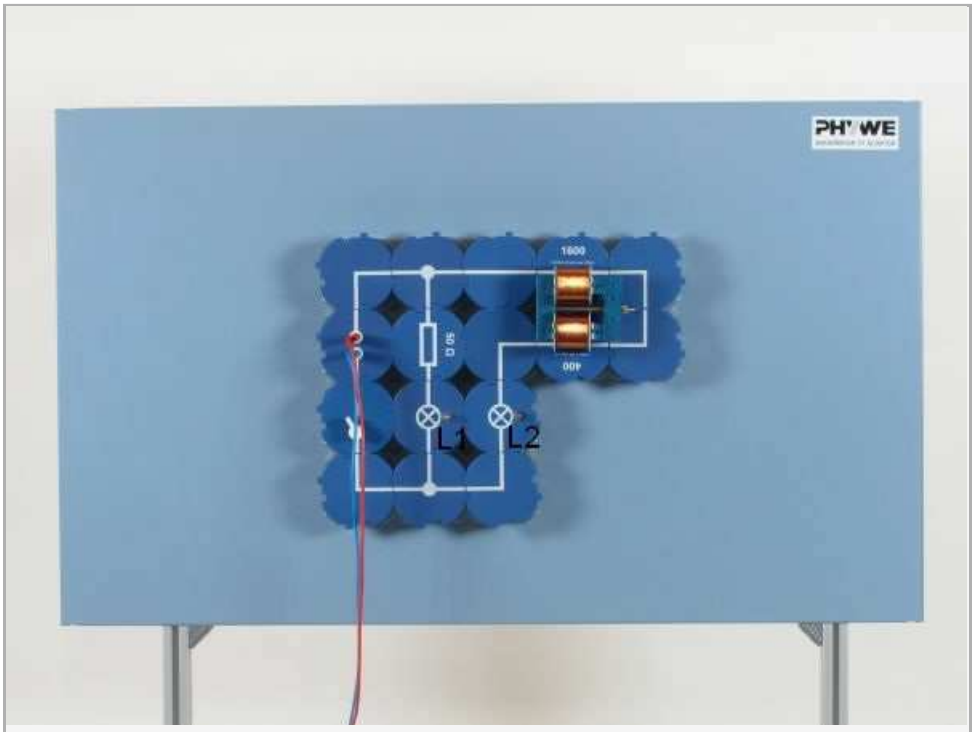

Fig. 1

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Observation and evaluation

Observation

1. When the circuit is closed, lamp L2 lights up a little later than lamp L 1. When the circuit is opened, L2 and L 1 go out simultaneously.
2. When the circuit is closed, the two lamps light up simultaneously. They also go out simultaneously.

Evaluation

When the circuit is closed, current begins to flow immediately and builds up a variable magnetic field in the coils that is considerably increased by the iron core . The changing of the magnetic field strength from 0 to its highest value results in an induction voltage that, as Lenz's law predicts, acts against its cause- the build up of the magnetic field - and so delays the growth of the coil current until its highest value has been reached. Therefore, lamp L2, which is in the part circuit with the coils, lights up later than L 1.

When the coil has no iron core, then the resulting magnetic field, or rather the change in it, is considerably less, and so generates a considerably lower induction potental. The two lamps light up without any visible delay.

That both lamps go out simultaneously when the circuit is opened can be explained by the fact that they are then connected in series. The induction current that is generated by the breakdown of the magnetic field on switching off must therefore flow through both lamps.

Remarks

The coils act simultaneously as field and induction coils. The voltage that results from the change in the coil current and the change this causes in the coil magnetic field is called the self-induction voltage: It acts, according to Lenz's law, against its cause, and is given by:

$U_i = -L(dI/dt)$.

where L is the self-induction coefficient or inductivity, which is measured in Henries (H). The coils used in the experiment have inductivities of $L = 50\ \mathrm{mH}$ and $L = 3\ \mathrm{mH}$ without iron core, an inductivities in the area of $L = 1700\ \mathrm{mH}$ and $L = 100\ \mathrm{mH}$ with iron core.

As the time difference between the lighting up of the two lamps is very small, the students should be expressly told to watch both lamps simultaneously. A more exact perception can be trained by several repeats.

The effect can be seen more clearly when a $R = 10\ \Omega$resistor (article no. 09412.1 0) is used in place of the $R = 50\ \Omega$ resistor, but then when the two lamps light up they do not have the same brightness.

For more detailed information on the course of voltage and current after switching-on, we recommend the use of a Cobra3 Basic Unit, as this can record the switching-on processes with a resolution $t = 1ms$.

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