Coils in alternating current circuit (Item No.: P1377200)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 10-13	Elektrizitätslehre	Elektromagnetische Induktion	Die Spule im Wechselstromkreis

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 self-induced voltage is generated in a coil in a direct current circuit when the circuit is closed or opened. They also know which direction the sel-finduced current has.
Based on this knowledge, they can probably predict what happens when alternating current flows through a coil. The first experiment demonstrates that the additional resistance, which coils possess in an alternating current circuit as opposed to their resistance in a direct current circuit, is dependent on frequency. Of course, there is no alternating voltage source used to provide a variable frequency in this experiment, but a similar effect can be achieved by switching the switch for direct voltage on and off at different rates.
The second experiment is used to provide a semi-quantitative analysis of the dependency of inductive resistance on the number of turns and the coil core.

Notes on setup and procedure

In the series connection of the coils with the core, make sure the students do not cross polarity since this would cause the magnetic fields of the coils to cancel each other out partially.
In the first experiment, the brightness of each of the two filament lamps is to be observed when the switch is rapidly opened and closed. To be able to see a difference in the brightness, the switching must be carried out very quickly.
If the switch is closed when the procedure is finished, it can be observed that lamp L2 gets even brighter whereas the brightness of L1 stays the same. This makes the difference even more distinct.
The students must change the measurement range in the second experiment because there should be a large discrepancy in the values for inductive resistance in the series of measurements.

Remarks

Make sure the students do not equate the difference between $R_\sim$ and $R\_$ with inductive resistance which is represented by the following equation

$X_L = \omega \cdot L = 2\,\pi \cdot f \cdot L$

$R_\sim$ is the impedance Z, and with $R\_ = R$, the following relationship applies:

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (\omega \times L)^2}$$

L is inductivity, which is measured in Henry (H).

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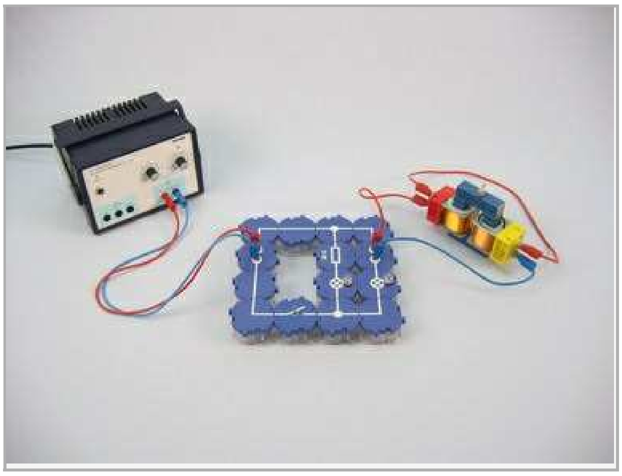
Task and equipment

Task

How does a coil act in an alternating current circuit?

Prove that a coil in an alternating current circuit possesses a resistance in addition to the ohmic resistance from its wound wire and investigate the factors responsible for this additional resistance.



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	Junction module, SB	05601-10	2
6	On-off switch module, SB	05602-01	1
7	Socket module for incandescent lamp E10, SB	05604-00	2
8	Resistor module 50 Ohm, SB	05612-50	1
9	Coil, 400 turns	07829-01	1
10	Coil, 1600 turns	07830-01	1
11	U-core	07832-00	1
12	Yoke	07833-00	1
13	Tightening screw	07834-00	1
14	Connecting cord, 32 A, 250 mm, red	07360-01	2
15	Connecting cord, 32 A, 250 mm, blue	07360-04	1
16	Connecting cord, 32 A, 500 mm, red	07361-01	2
17	Connecting cord, 32 A, 500 mm, blue	07361-04	2
18	Filament lamps 4V/0.04A, E10, 10	06154-03	2 pieces
19	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
20	Multi-range meter, analogue	07028-01	1

Set-up and procedure

Set-up

First experiment

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

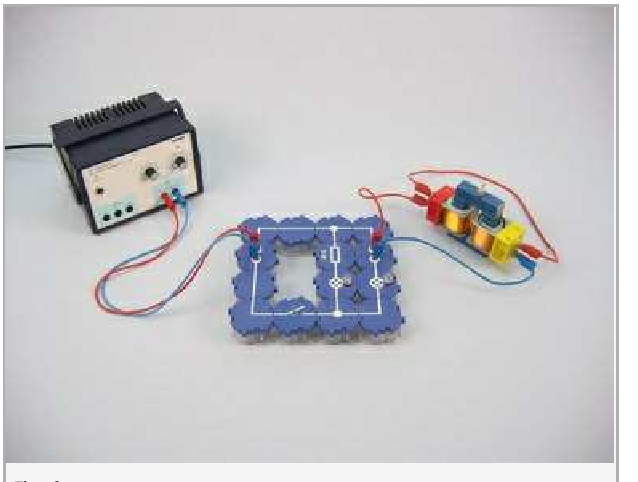


Fig. 2

Second experiment

Set up the experiment as shown in Fig. 3. and Fig. 4. Select a measurement range of 30 mA-. The circuit should be opened initially. The coils should be connected in series as in the first experiment initially.

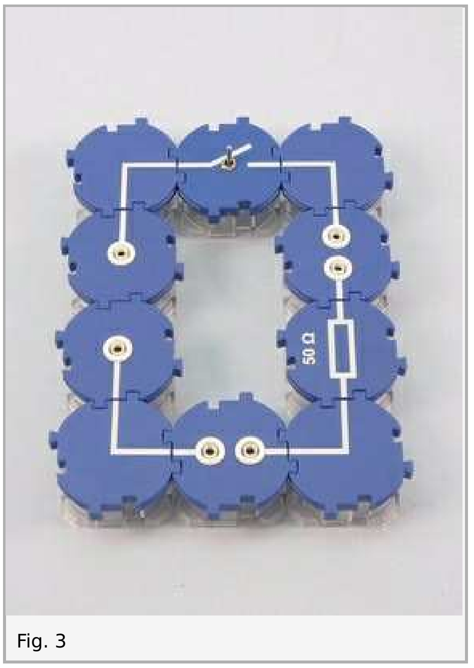


Fig. 3

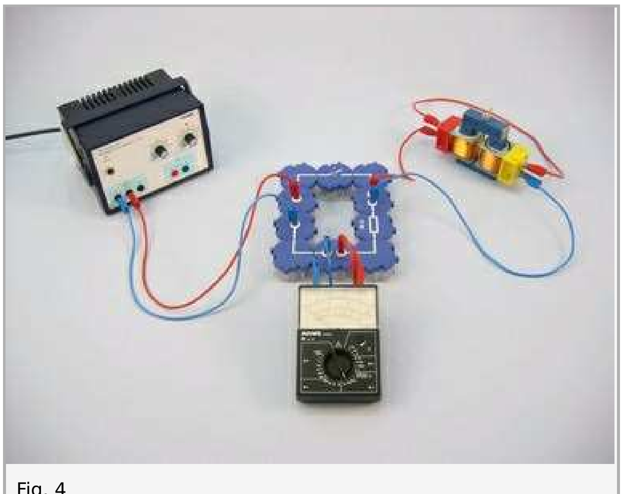


Fig. 4

Procedure

First experiment

- Switch on the power supply unit and set the direct voltage to 12 V.
- Close the circuit, observe the brightness of the filament lamps and compare. Note your results under Result - Observations 1 in the report.
- Toggle the on/off switch back and forth slowly at first, and then more and more quickly. Observe the filament lamps while doing this. Note your observations under Result - Observations 2.
- Switch off the power supply unit.

Second experiment

- Set the alternating voltage to 6 V and switch on the power supply unit.
- Close the circuit, measure the current, and enter the value in Table 1 in the report.
- Remove the coil with 400 turns from the circuit (thereby reducing the total number of turns in the series connection from 2000 to 1600). Measure the current and note the value.
- Change the measurement range to 300 mA-. Remove the coil with 1600 turns and replace it with the coil with 400 turns and proceed as above.
- Leave the coil with 400 turns in the circuit. Remove the yoke (I-core) of the iron core from the circuit. Measure the current and note the value.
- Finally, remove the U-core from the circuit. Measure the current and note the value.
- Switch off power supply unit.

Report: Coils in alternating current circuit

Result - Observations 1

Note your observations.

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Result - Observations 2

Note your observations.

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Result - Table 1

Record your measured values in the table.

Calculate the values for impedance *R*~ resulting from the measurements entered in Table 1 and enter the results in the table.

Enter the value for the combined resistance R_ represented by the coil and resistor in the last column of Table 1 (add the values for resistance printed on the components).

Coil with	*U* in V	*I* in mA	$R_{\sim}$ in Ω	*R*_ in Ω
2000 turns, U- and I-core	1	1	1	1
1600 turns, U- and I-core	1	1	1	1
400 turns, U- and I-core	1	1	1	1
400 turns and U-core	1	1	1	1
400 turns	1	1	1	1

Evaluation - Question 1

What conclusion can you draw from the observations you made under Observations 2 regarding the values for current and resistance in both branches?

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Evaluation - Question 2

Compare the resistance values in Table 1 for the series connection of the coil and the resistor line for line for both the direct current and alternating current circuits.
The discrepancies can only be the result of the behaviour of a coil in the alternating current circuit. Explain the difference between the values for resistance of a coil in direct current and alternating current circuits.

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Evaluation - Question 3

The differences between $R\sim$ and $R\_$ are caused by the inductive resistance of each coil in the alternating current circuit.
Based on the results of both experiments, explain the factors responsible for inductive resistance.

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