Coils in alternating current circuits (Item No.: P1400100)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 16-19
Topic: Electricity
Subtopic: Electromagnetic induction
Experiment: Coils in alternating current circuits

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	2 Students

Additional Requirements:

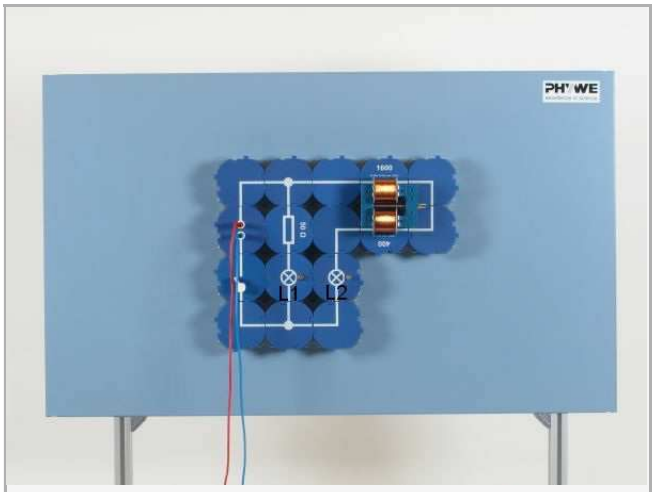
Experiment Variations:

Keywords:

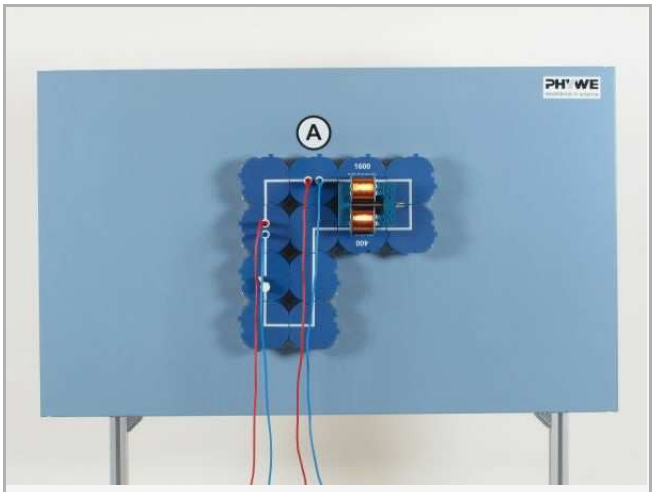
Principle and equipment

Principle

It is to be demonstrated that a coil in an alternating current circuit has, alongside its ohmic resistance, an additional resistance that can be changed to a geat extent by a variable iron core in the coil.



Experimental set-up Part 1



Experimental set-up Part 2

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	1
2	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
3	Demo Physics board with stand	02150-00	1
4	Coil 400 turns, module DB	09472-01	1
5	Coil 1600 turns, module DB	09472-02	1
6	Switch on/off, module DB	09402-01	1
7	U-core	07832-00	1
8	Socket for incandescent lamp E10 ,module DB	09404-00	2
9	Connector interrupted, module DB	09401-04	2
10	Resistor 50 Ohm,module DB	09412-50	1
11	Electr.symbols f.demo-board,12pcs	02154-03	1
12	Yoke	07833-00	1
13	Connector, straight, module DB	09401-01	2
14	Connector, angled, module DB	09401-02	6
15	Connector, T-shaped, module DB	09401-03	2
16	Filament lamps 4V/0.04A, E10, 10	06154-03	1
17	Tightening screw	07834-00	1
18	Connecting cord, 32 A, 1000 mm, red	07363-01	2
19	Connecting cord, 32 A, 1000 mm, blue	07363-04	2

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Set-up and procedure

1st. Experiment

- Set up the experiment as shown in Fig. 1; Fit the coils with a common U-core and press the yoke tightly on the U-core with the tightening screw
- With the switch open, turn on the power supply and set a direct voltage of 12 V
- Close the circuit ; obseNe and compare the brightnesses of the filament lamps L1 and L2 (1)
- Close and open the circuit in ever quicker succession while observing the lamps (2)

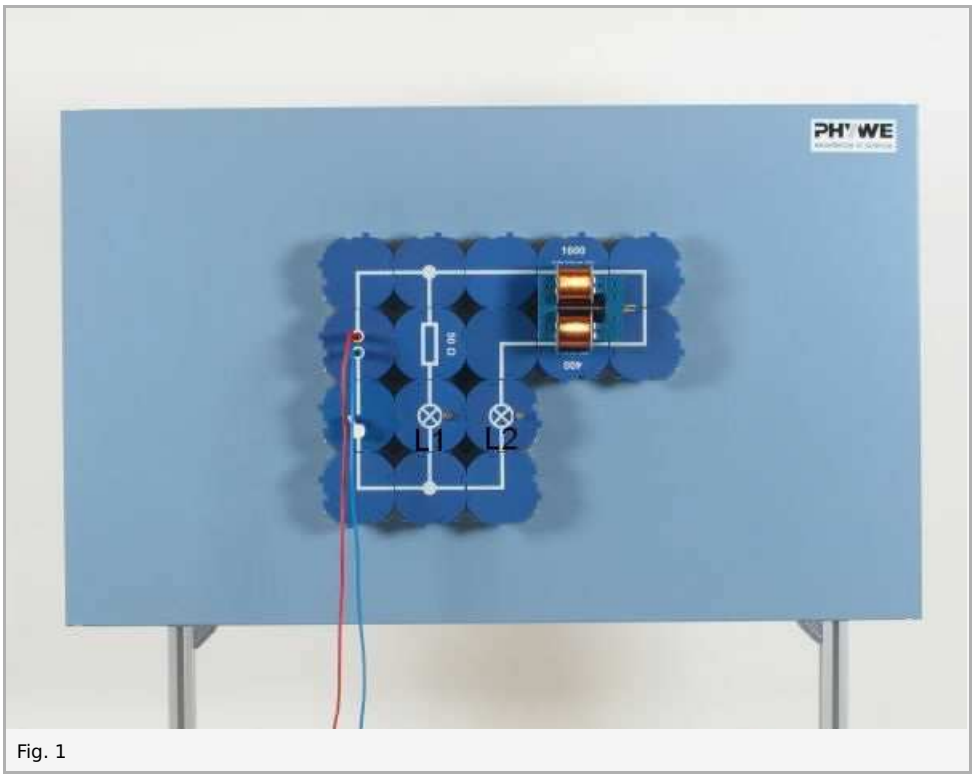

Fig. 1

2nd. Experiment

- Set up the experiment as shown in Fig. 2, set the 10 mA~ measurement range
- With the switch open, turn on the power supply and set an alternating voltage of 4 V
- Close the circuit; measure the current and enter it in Table 1
- Replace the 400 turn coil with the second straight connector building block; measure and note the current for the i 600 turn coil with enclosed iron core
- Switch to the 1 00 mA~ measurement range; replace the 1600 turn coil by the 400 turn coil; again measure and note the current
- Set the 1 A~ measurement range; remove the yoke from the iron core; measure the current and note it
- Remove the U-core and push the yoke in the coil; measure the current and note it
- Set the 3 A~ measurement range; remove the yoke; measure the current and note it

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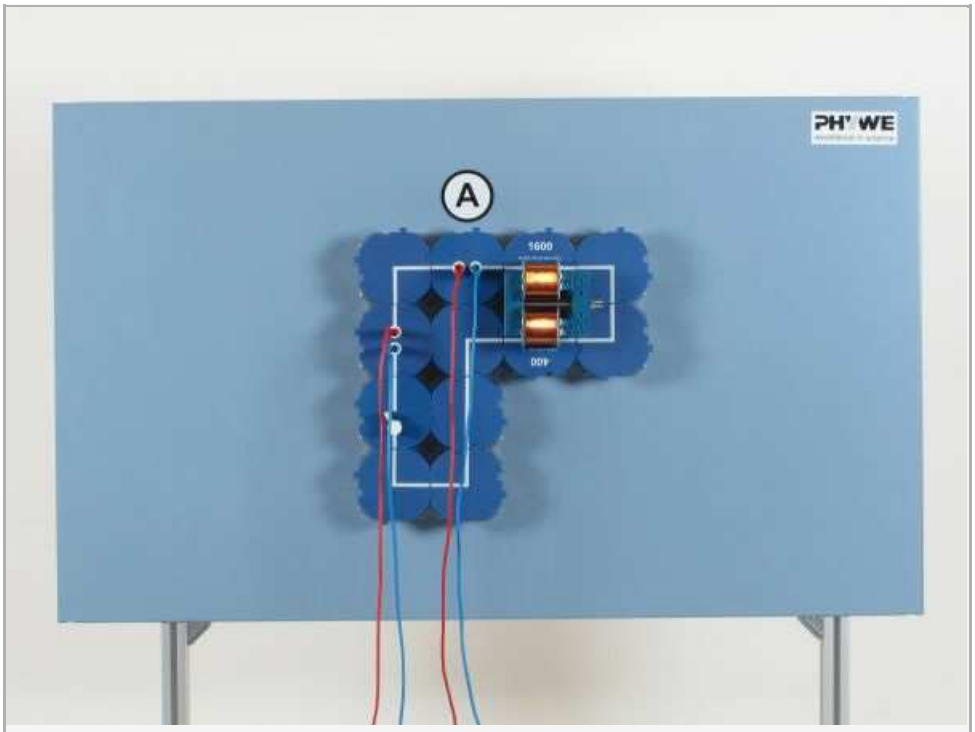

Fig. 2

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Observation and evaluation

Observation

1. Both lamps light up and are equally bright.
2. Lamp L 1 still lights up brightly, but lamp L2 lights up all the more weaker, the quicker the switching frequency.

Table 1

Coil with	I/mA	R~$/\Omega$	R-$/\Omega$
1600 turns/400 turns, U-core and yoke	2.7	1480	48
1600 turns, U-core and yoke	4.1	976	45
400 turns, U-core and yoke	40	100	3
400 turns and U-core	450	8.9	3
400 turns and yoke	700	5.7	3
400 turns without iron core	1350	3.0	3

Evaluation

From the 1st. experiment we find that the resistance in the part of the circuit containing the coil is higher, the higher the switching frequency. The resistance in the other part is independent of the switching frequency.

The various values of the resistance that the coils have in the alternating current circuit are obtained from the measured values obtained in the 2nd experiment (see Table 1, column 3). It can be recognized that the resistance value is higher, the higher the number of turns on the coil.

Further to this, it is dependent on the coil core and is greatest when this is closed. The resistance values that are printed on the resistors, and show the resistance that they have in direct current circuits, are shown in Table 1, column 4. The comparison of each R with the appropriate $R-$ shows that R is always greater than $R-$.

A coil in an alternating current circuit therefore has an additional resistance to its direct current resistance. This additional resistance is called the inductive resistance, as it is caused by a self-induction voltage that is generated in the coil by the periodic building up and breaking down of a magnetic field. It works in the opposite direction to the applied alternating voltage, according to Lenz's law, and so reduces the current strength.

Altogether, we have: A coil in an alternating circuit has, alongside the ohmic resistance, an inductive resistance that is dependent on the frequency of the alternating current, the number of turns on the coil and the core of the coil.

Remarks

The ‚additional" resistance of a coil in an alternating current is not given by the difference between R and $R-$, as may be assumed by the students: This inductive resistance $X_L = \omega * L = 2\pi * f * L$ Lis linked by R , to the apparent resistance Z (the impedance) by the relationship:

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

The resistance in the direct current circuit (R) is described as the ohmic resistance to differentiate it from the inductive resistance; L is the inductivity of the coil, that is given in Henries (H).

Coils with iron cores that are used in commercial installations to limit the current are called choke coils. They are used, for example, in the operation of fluorescent tubes.

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