Generation of induction voltages by an electromagnet (Item No.: P1399000)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 16-19	Electricity	Electromagnetic induction	Generation of induction voltages by an electromagnet

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

Additional Requirements:

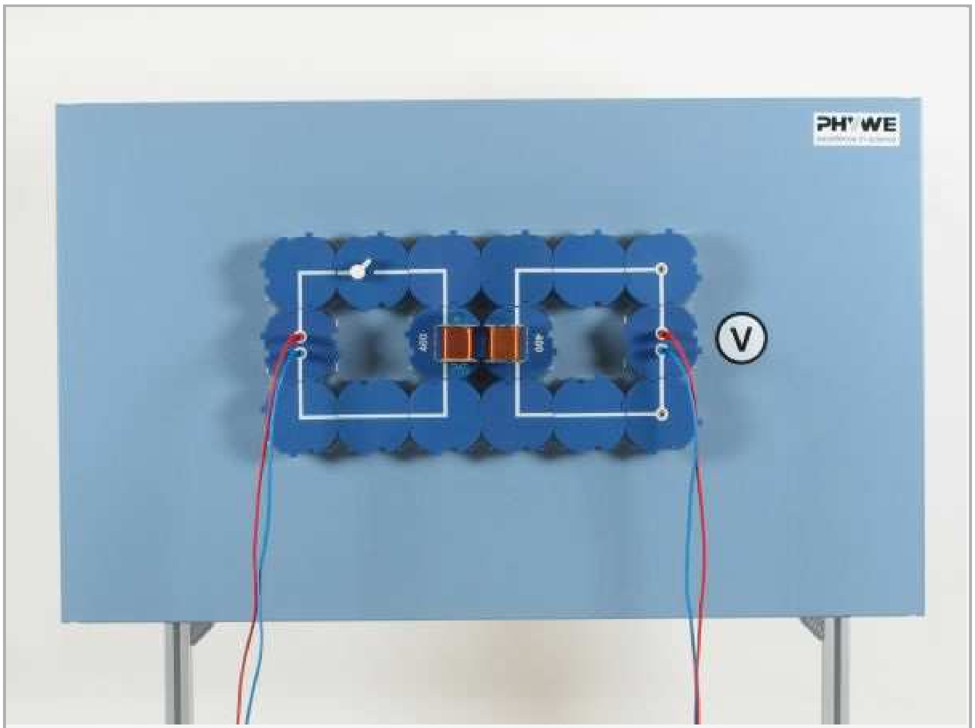
Experiment Variations:

Keywords:

Principle and equipment

Principle

It is to be demonstrated that an electromagnet can also be used to generate induction voltages without mechanical movement.



Experimental set-up

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	2
5	Switch on/off, module DB	09402-01	1
6	U-core	07832-00	1
7	Connector interrupted, module DB	09401-04	2
8	Electr.symbols f.demo-board,12pcs	02154-03	1
9	Yoke	07833-00	1
10	Connector, straight, module DB	09401-01	3
11	Connector, angled, module DB	09401-02	6
12	Connector, angled with socket, module DB	09401-12	2
13	Connecting cord, 32 A, 1000 mm, red	07363-01	2
14	Connecting cord, 32 A, 1000 mm, blue	07363-04	2

Set-up and procedure

- Set up the experiment as shown in Fig. 1; insert the 1-core (yoke) in the coil in the excitation circuit; select the 10-0-10 m V measurement range
- With the switch open, set the power supply to a voltage of 5 V- and a current limit of 1 A
- Close and open the circuit containing the electromagnet (excitation circuit) several times while observing the measuring instrument (1)
- With the switch closed, vary the power supply voltage, and so the excitation current for the electromagnet, several times within the 0 ... 5 V range; observe the measuring instrument (1)
- With the switch open, replace the 1-core by the U-core, so that this is inserted in both the excitation coil and the induction coil
- Close and open the excitation circuit again several times; then, as previously, change the excitation current by varying the voltage; observe the measuring instrument (2)
- With the switch open, place the 1-core on the U-core; carry out the same procedure as above while observing the measuring instrument (3)

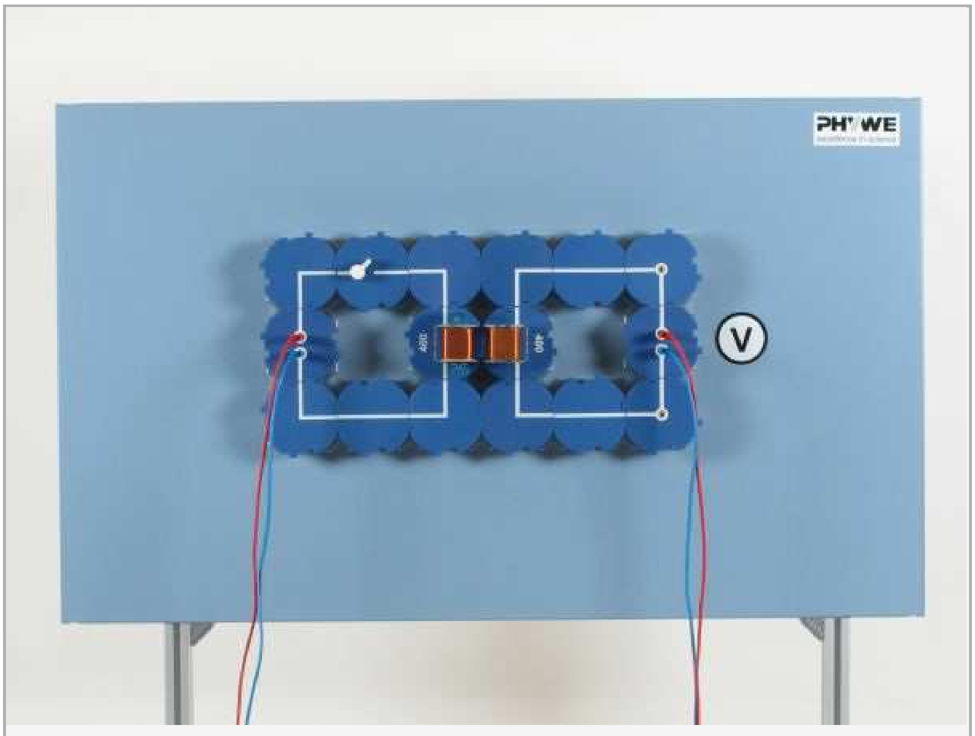


Fig. 1

Observation and evaluation

Observation

1. The instrument that measures the induction voltage deflects to the right or the left - but only to a small extent - when the current to the electromagnet is switched on or off. This also happens when the current to the electromagnet is being continually increased or decreased, whereby the induction voltage is even smaller than tha on switching on or off.
2. When the coil of the electromagnet and the induction coil have the same common iron core, then the induction voltage that is attained is higher than when there is only the 1-core in the electromagnet.
3. The attainable induction voltage is highest, when the common iron core of the field coil and induction coil is closed.

Evaluation

In this experiment, the induction coil spans part of the magnetic field of the electromagnet. Any change in the magnetic field of the electromagnet therefore generates an induction voltage which, when all other conditions are the same, is all the higher the more of the magnetic field of the electromagnet that is spanned by the induction coil. This part is greatest with the iron core; the reason why the induction voltage reaches a maximum with it. it is therefore possible to generate an induction voltage, without relative movement of a coil and a magnet to each other.

In general it is valid, that a voltage is induced in a coil as long as the magnetic field that the coil spans is subject to change.

Remarks

There are therefore two possibilities of inducing a voltage; the field that is spanned by the induction coil must be changed either by relative movement of the magnet (permanent magnet or electromagnet) and the induction coil, or by varying the field strength of an electromagnet. Both possibilities are included in the induction law:

$$U = -N\frac{\Delta\phi}{\Delta t} = -N\frac{\Delta(B \cdot A)}{\Delta t}$$

whereby B is the magnetic induction, A is the effective cross-sectional area and N is the number of turns of the induction coil.

B can be changed by changing the field strength, A for example by turning the induction coil in a (homogenous) magnetic field.

In technical applications, the first named possibility is used in transformers, and the second one in generators. The ADM 2 reacts in a very different way when the excitation current is switched on to when it is switched off. This is because of the different speeds of change of the magnetic flux on switching on and off.