UE3040200

INDUCTION IN A MOVING CONDUCTOR LOOP

EXPERIMENT PROCEDURE

- **Measure the induced voltage as a function of the velocity of the conductor loop.**
- **Measure the induced voltage as a function of the number of turns in the conductor loop.**
- **Compare the sign of the induced voltage when moving the conductor loop into the field or out of it.**
- **Compare the sign of the induced voltage when the direction of motion is changed.**
- **Measure the induced voltage in a conductor loop with a single turn of variable area.**

OBJECTIVE

Measure the induced voltage in a conductor made into a loop as it moves through a magnetic field

SUMMARY

The change in magnetic flux that is needed to induce a voltage in a conductor loop can be caused by a movement of the loop. Such a situation results, for example, when a conductor loop orientated with its plane perpendicular to a homogeneous magnetic field is moved into the magnetic field or withdrawn from it at a constant velocity. In the first case the magnetic flux increases at a rate determined by the relevant parameters, whereas in the second case it decreases in a similar way. Therefore the induced voltages are of opposite signs.

REQUIRED APPARATUS

Quantity	Description	Number
1	Induction Apparatus	1000968
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	1003312 or
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	1003311
1	Analogue Multimeter AM50	1003073
1	Set of 15 Safety Experiment Leads, 75 cm	1002843
1	Mechanical Cumulative Stopwatch	1002810
Additionally recommended		
1	Measurement Amplifier (230 V, 50/60 Hz)	1001022 or
	Measurement Amplifier (115 V, 50/60 Hz)	1001021

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BASIC PRINCIPLES

The term electromagnetic induction refers to the process whereby an electric voltage is generated around a conductor loop when the magnetic flux passing through the loop is changed. Such a change in flux can result from a change in the magnetic field strength or from movement of the conductor loop.

To describe the relationships involved, a U-shaped conductor loop with a moveable crossbar is often considered. The plane of this loop is aligned perpendicular to a homogeneous magnetic field of flux density B (see Fig. 1). The magnetic flux through the area limited by the cross-bar is

(1) $$\Phi = B \cdot a \cdot b$$

a: Width, b: Length of the loop.

If the cross-bar is moved with a velocity v, the flux changes, since the length of the loop is changed. The rate of change of the flux is

(2) $$\frac{d\Phi}{dt} = B \cdot a \cdot v$$

and in the experiment it is observed as a voltage

(3) $$U = -B \cdot a \cdot v$$

which is in the order of microvolts but can be measured using the amplifier that is recommended as additional equipment.

A much greater induced voltage is obtained if a conducting loop with multiple turns on a rigid frame is moved through the magnetic field. When the frame is only partly projecting into the magnetic field, the situation is as shown schematically in Figure 1. The movement of the loop into the magnetic field results in a change of flux at the following rate

(4) $$\frac{d\Phi_1}{dt} = B \cdot N \cdot a \cdot v$$

N: Number of turns,

and this can be measured as an induced voltage.

(5) $$U_1 = -B \cdot N \cdot a \cdot v$$

As soon as the conductor loop is completely in the magnetic field, the induced voltage returns to zero. No further change occurs until the loop begins to move out of the magnetic field. Now the magnetic flux is decreasing and the induced voltage is of opposite sign compared with the initial situation. A change of sign also occurs if the direction of motion of the loop is reversed.

In this experiment, the voltage driving an electric motor used to pull the conductor loop along is varied. This provides a range of different constant velocities. The direction of rotation of the motor can also be reversed. The coil provided also has an intermediate tapping point, so that the induced voltage can be measured for three different values of N, the number of turns.

EVALUATION

Calculate the velocity from the time t required for the conductor loop to move completely through the magnetic field and the corresponding distance L

$$v = \frac{L}{t}$$

Then draw a graph of the induced voltage U as a function of the velocity v. The data will be found to lie on a straight line through the origin (see Fig. 2).

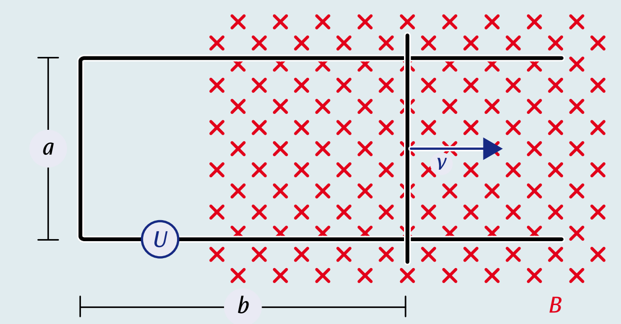

Fig. 1: The change of the magnetic flux through the conducting loop when its area is altered

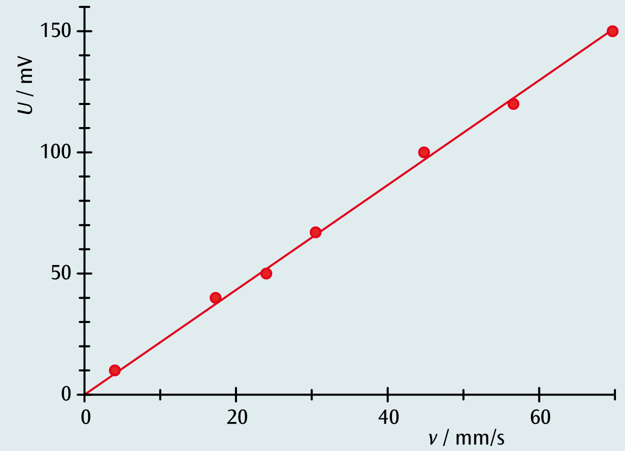

Fig. 2: Induced voltage as a function of the velocity of the conducting loop