DEPARTMENT FOR EDUCATION AND SCIENCE OF UKRAINE
NATIONAL TECHNICAL UNIVERSITY
“DNIPRO POLYTECHIC”

PHYSICS.

STUDY OF THE DEPENDENCE OF THE COEFFICIENT OF THE USEFUL ACTION OF THE SOURCE OF CURRENT AND ITS POWER FROM THE LOAD RESISTANCE

METHODICAL POINTING TO LABORATORY WORK

for the section “Electrodynamics” of students of all specialties in “Physics” discipline

Dnipro
2018

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Physics. Study of the dependence of the coefficient of the useful action of the source of current and its power from the load resistance. Methodical pointing to laboratory work for the section “Electrodynamics” of students of all specialties in “Physics” discipline / L.I. Bartashevska, A.S. Zaitsev. – D.: NTU “Dnipro polytechnic”, 2018. – 5 p.

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Approved by the methodical commission for the direction “Mining” (protocol № from) according to presentations of the chair physics (protocol № from).

Methodical materials are necessary for independent preparation of the students for laboratory work and control of the normative discipline “Physics”. The theoretical information, device and installation used considered.

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The recommendations are focused of student’s academic work.

Laboratory work № 3.32

STUDY OF THE DEPENDENCE OF THE COEFFICIENT OF THE USEFUL ACTION OF THE SOURCE OF CURRENT AND ITS POWER FROM THE LOAD RESISTANCE

Devices and equipment: 1) current source 2) resistance store 3) milliammeter

Purpose of the work: obtaining dependencies from the load resistance: 1) the total power released in the electrical circuit 2) the useful power 3) the efficiency of the current source.

Description of the device and theoretical information

The use of the current source energy is an important practical issue. An electrical circuit containing a current source and a load whose resistance R can be changed is shown in Fig. 1.

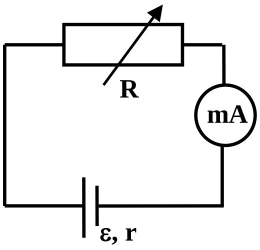

Fig. 1.

For a closed circuit, the work performed on the charge *dq* carried along the chain is

$$dA = \varepsilon\, dq \qquad (1)$$

The total power, developed by the current source,

$$P = \frac{dA}{dt} = \varepsilon \frac{dq}{dt} = \varepsilon I \qquad (2)$$

Using Ohm's law for a closed circuit

$$I = \frac{\varepsilon}{R + r} \qquad (3)$$

after substituting into (2), we obtain

$$P = \frac{\varepsilon^2 R}{R + r} \qquad (4)$$

where *R* is the load resistance (resistance of the consumer of electric energy), *r* is the internal resistance of the source.

As can be seen, the total power developed by the current source, as seen from (4), is maximal with a short circuit (*R* = 0) and is released as heat at its internal resistance, being completely useless. With increasing *R*, the total power decreases, tending to zero as $R \to \infty$.

In the load, only a part of the total power is allocated. It is called useful power.

$$P_U = I^2 R = \frac{\varepsilon^2 R}{(R + r)^2} \qquad (5)$$

Assuming that for a current source the quantities ε and r are constants, the net power P_U is a function of only the load resistance *R*

$$P_U = f(R).$$

It can be seen from equation (4) that for *R* = 0 (short circuit) and for $R = \infty$ (the circuit is closed) $P_U = 0$.

There is an optimal value of the resistance *R* at which this current source gives the maximum power to the consumer. In order to determine under what condition the useful power will have a maximum value, it is necessary to find the value of $\frac{dP_U}{dR}$ and equate it to zero

$$\frac{dP_U}{dR} = \frac{\varepsilon^2 (R+r)^2 - 2(R+r)\varepsilon^2 \cdot R}{(R+r)^4}$$

It follows that P_U has a maximum at *R* = *r*.

In practical use of current sources, it is important not only the selected useful powers, but also the efficiency factors η of the sources.

$$\eta = \frac{P_H}{P} = \frac{I^2 R}{I^2 (R+r)} = \frac{R}{R+r} \qquad (6)$$

It follows that η will be the greater, the greater the load resistance R in comparison with the internal resistance r of the current source.

The efficiency factor η is 0 for *R* = 0, equal to 0.5 for *R* = *r* and tends to 1 for an unlimited growth of *R*.

Thus, the requirements for obtaining the highest power and the highest efficiency can not be met.

Sequence of measurements

1. Assemble the electrical circuit in accordance with Fig. 1
2. Changing the load resistance every 5 ohms, take the indication of a milliammeter *I*. Enter the values of *R* and *I* in the table

№	R, ohm	I, mA	P_u, w	P, w	r, ohm	η
1.						
2.						
3.						
...						
n						

3. Using the formula $P_U = I^2 R$, calculate the value of the useful power for all values of the load resistance. Obtain the values of P_U in the table. Construct a graph of the dependence $P_U = f(R)$ and determine the resistance value of the current source r from the graph. Put it in the table.
4. Using the formula $P = I^2 (R+r)$, calculate the power value for different values of the load resistance. Obtain the obtained values of *P* in the table. Construct a graph of the dependence $P = f(R)$.
5. From the formula $\eta = \frac{R}{R+r}$ calculate the efficiency at different values of the load resistance. Record the data in the table. Construct a graph of the dependence $\eta = f(R)$.

Control questions

1. Formulate Ohm's law for a closed circuit.
2. Formulate the Joule-Lenz law in integral form.
3. How, from the data obtained as a result of the experiment, can we determine the "electromotive force" of this source? Identify it.

4. How, knowing the value of the current I_1 and I_2 for different values of the load resistance R_1 and R_2, determine the resistance of the current source? Calculate the resistance of the source by the method proposed by the experiment. Compare the values of r obtained by different methods (by calculation and by the graph $P = f(R)$.

Literature

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