The internal resistance of a voltage source (Item No.: P1373200)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Elektrizitätslehre
Subtopic: Der elektrische Widerstand
Experiment: Der Innenwiderstand einer Spannungsquelle

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

A commercially available dry battery or single cell is extremely suitable for this experiment on the internal resistance of a source of voltage. It has an internal resistance which is high enough to be measured well, and it can be easily replaced if inattentiveness should cause it to be destroyed by too long exposure to an overload.
The power supply is not suitable for this determination of internal resistance because it is voltage stabilised.

Notes on setup and procedure

Highest attentiveness is necessary when reading off measured values during the short circuit, because when this is held for too long, there is a large drop in the voltage to be measured and the battery becomes unusable. When at least two students work together, they should each read simultaneously one of the measured values for U_T and I, to minimise the duration of the short circuit. Otherwise, a student should twice briefly make the short-circuit, and in each case read one of the measured values.

Remarks

One group could possibly examine how a "used" battery behaves in the case of $I = 0$ or when short-circuited, or even under a low load. The short-circuit current, and so the internal resistance, are highly dependent on the charging condition of the battery. The measurement results obtained by the separate groups will differ because of this.
A battery (source of voltage) is of high quality, when its short-circuit current is particularly high, and thereby its internal resistance particularly low.
We recommend that possibly one group examines the short-circuit behaviour, and informs the rest of the students on their results. This would avoid other batteries from suffering a loss of quality. We have deliberately not suggested changing to the 1 V − measurement range when measuring U_T during the short-circuit, as its measurement range is insufficient, when the switch is opened!

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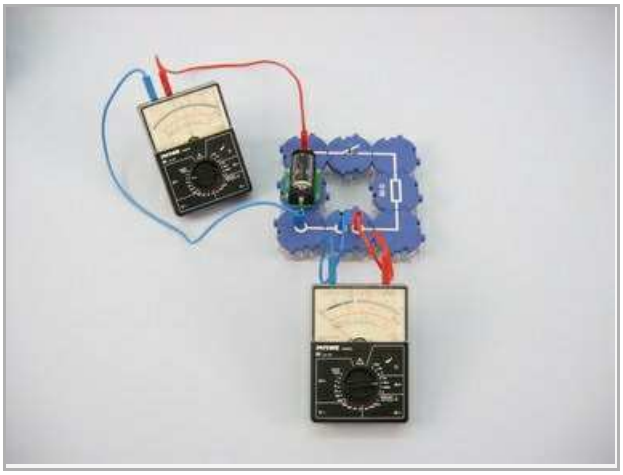
Task and equipment

Task

Do voltage sources also have a resistance?

Connect resistances of various sizes in a circuit, then examine the internal resistance of the voltage source R_i by measuring its current I and terminal voltage U_T.



Equipment

Position No.	Material	Order No.	Quantity
1	Angled connector module, SB	05601-02	2
2	T-shaped connector module, SB	05601-03	2
3	Interrupted connector module, SB	05601-04	2
4	Angled connector module with socket, SB	05601-12	2
5	On-off switch module, SB	05602-01	1
6	Resistor module 50 Ohm, SB	05612-50	1
7	Socket module for incandescent lamp E10, SB	05604-00	2
8	Connecting cord, 32 A, 250 mm, blue	07360-04	1
9	Connecting cord, 32 A, 250 mm, red	07360-01	1
10	Connecting cord, 32 A, 500 mm, blue	07361-04	1
11	Connecting cord, 32 A, 500 mm, red	07361-01	1
12	Straight connector module, SB	05601-01	2
13	Battery cell, 1.5 V, baby size, type C	07922-01	1
14	Filament lamp 6 V/3 W, E10, 10 pcs.	35673-03	1
15	Multi-range meter, analogue	07028-01	2
16	Battery holder module (C type), SB	05605-00	1

Set-up and procedure

Set-up

Set up the circuit as shown in Fig. 1 and Fig. 2, with the switch open.

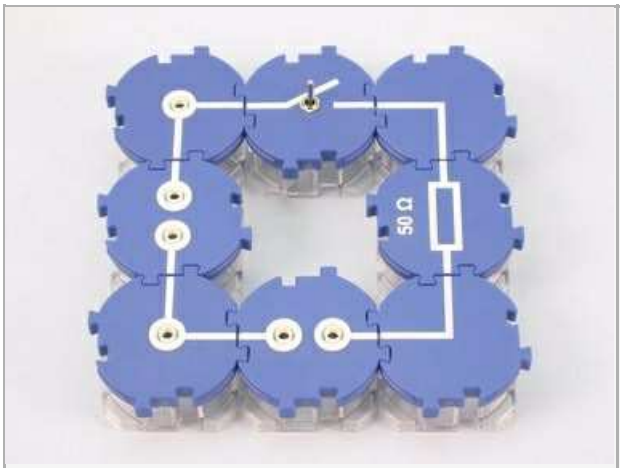


Fig. 1


Fig. 2

Procedure

- Select the 3 V− and 30 mA− measurement ranges.
- Measure the terminal voltage U_T for $I = 0$, i.e. without a load on the voltage source; note the measured value in Table 1 in the report.
- Close the circuit, read off the terminal voltage U_T and current I (under load); note the measured values in Table 1.
- Open the circuit and replace the resistor with a filament lamp; change the ammeter to the 300 mA− measurement range.
- Close the circuit, again read off U_T und I and note the measured values.
- Open the circuit and connect in a second filament lamp in parallel (Fig. 3).
- Close the circuit, again read off U_T und I and note the measured values.
- Open the switch and replace the filament lamps with a connector module (Fig. 4); change the ammeter to the 3 A− measurement range.
- Briefly (!) close the switch, during the short circuit read off U_T and I and note the values in Table 1.

Note: The short circuit current must only flow for a very short time, to avoid damage to the current source.

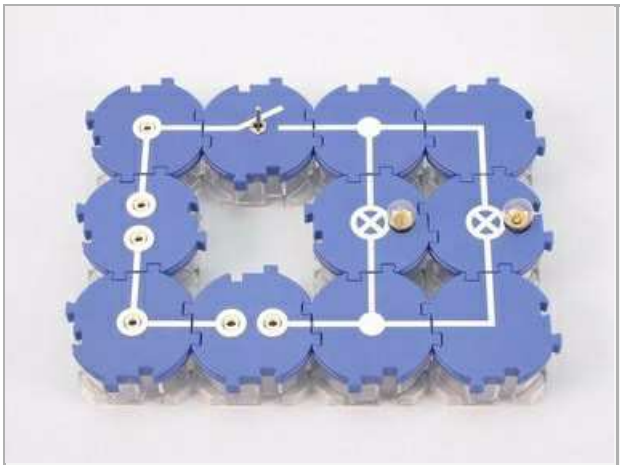


Fig. 3

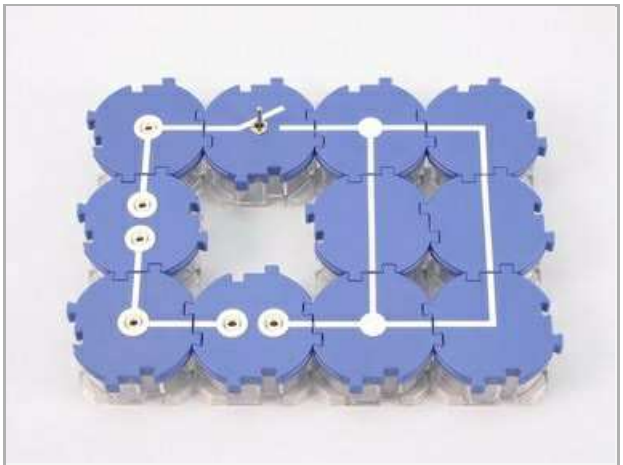


Fig. 4

Report: The internal resistance of a voltage source

Results – Table 1

Record the measured values in the table 1.

Load I in A	Terminal voltage U_T in V
0	1
1	1
1	1
1	1
1	1

Evaluation – Question 1

Formulate the relationship between the terminal voltage U_T and the load I in writing below.

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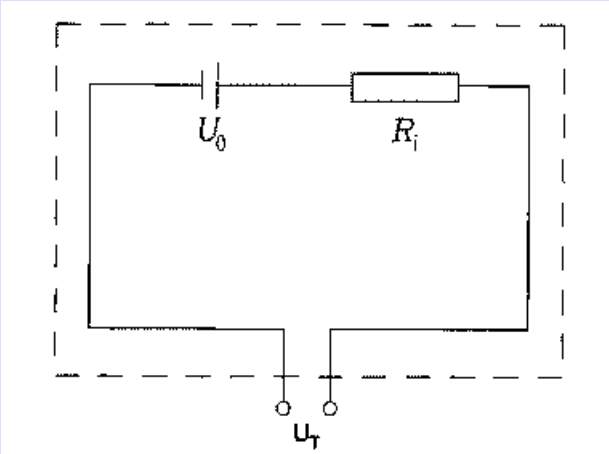
Evaluation – Question 2

Here you can see a so-called alternative circuit diagram for the voltage source with its internal resistance R_i. Under load, the voltage $R_i \times I$ drops across R_i. The voltage that the voltage source supplies when not under load (i.e. with $I = 0$ A) is designated U_0. Formulate the relationship between U_0 and U_T in an equation. (Note: remember the law of series connection $U_t = U_1 + U_2$.)



Evaluation – Question 3

Rearrange the equation found in 2 for R_i and use the values measured during the short-circuit in Table 1 to calculate the internal resistance R_i for the voltage source used.

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