How to calculate total current and total resistance in a parallel circuit

EEP 2.3 | S

Problem
Investigate the relationship between total current and partial current and between total resistance and partial resistance in a parallel circuit.

Equipment

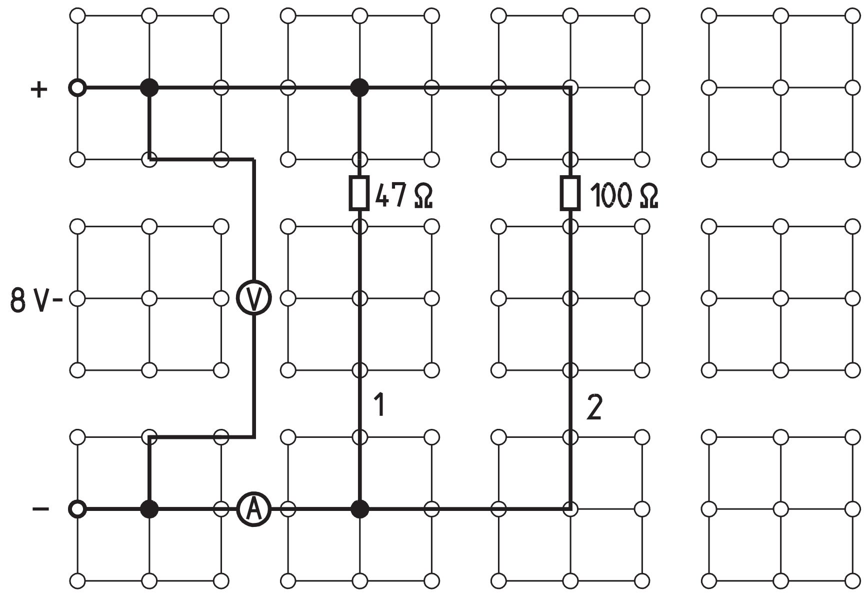
Plug-in board	06033.00	1
Resistor, 47 Ω	39104.62	1
Resistor, 100 Ω	39104.63	1
Wire building block	39120.00	5
Connecting cables, 25 cm, red	07360.01	1
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	2
Connecting cables, 50 cm, blue	07361.04	2
Multi-range meter	07028.01	2
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure
— Set up experiment as shown in Fig. 1. Select measurement range of 300 mA-.
— Switch on power supply unit and set direct voltage to 8 V.
— Measure current in unbranched part of circuit and enter value in Table 1.
— Remove wire building block 1 and put the current meter in its place. Measure partial current I_1 and note.
— Now, remove wire building block 2 and put the current meter in its place. Measure partial current I_2 and note.
— Switch power supply unit off.

Measurement Results
Table 1

U / V	I_T / mA	I_1 / mA	I_2 / mA
8			

Fig. 1



Evaluation

1. A general relationship is apparent from Table 1 (even though the measurements are slightly off). Explain this relationship and write an equation to express it.

2. Using the measurements from Table 1, calculate the resistance values R_T, R_1 and R_2 as well as the reciprocal values and enter the results in Table 2.

Table 2

$\frac{R_T}{\Omega}$	$\frac{R_1}{\Omega}$	$\frac{R_2}{\Omega}$	$\frac{1/R_T}{1/\Omega}$	$\frac{1/R_1}{1/\Omega}$	$\frac{1/R_2}{1/\Omega}$

A general relationship is apparent from the values on the right of the Table 2 (again, even though the measurements may be slightly off). Explain this relationship and write an equation to express it.

3. Compare total resistance R_T with the values for partial resistance (Table 2, to the left).
   What is apparent from this comparison?
   Explain why this must be true.

4. Rewrite the equation from question 2 in terms of R_T .

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This experiment demonstrates how electrical appliances in a household are connected. Generally, some of the students will already know that this is a parallel circuit.
Although most students should be able to make an accurate theoretical prediction about total current (that is, if they have the right notions about electrical current), they must first carry out this experiment before being able to comment on total resistance.

Notes on Set-Up and Procedure

The circuit for measuring the correct current as shown in Fig. 1 was selected because it guarantees good measurement results in consideration of the ratio between the values for internal resistance of the meter and the resistance values R_1 and R_2.

Measurement Results

Table 1

U / V	I_T / mA	I_1 / mA	I_2 / mA
8	220	154	75

Evaluation

1. In a parallel circuit, total current is equivalent to the sum of the values for partial current:

$$I_T = I_1 + I_2.$$

2. Table 2

$\frac{R_T}{\Omega}$	$\frac{R_1}{\Omega}$	$\frac{R_2}{\Omega}$	$\frac{1/R_T}{1/\Omega}$	$\frac{1/R_1}{1/\Omega}$	$\frac{1/R_2}{1/\Omega}$
36	52	107	0.028	0.019	0.009

In a parallel circuit, the reciprocal of total resistance is equivalent to the sum of the reciprocal of the values for partial resistance:

$$1/R_T = 1/R_1 + 1/R_2.$$

3. Total resistance is smaller than the smallest partial resistance.
   This must be true because there is also a current flowing through a resistor connected in parallel to the resistor with the least partial resistance. Total current, therefore, is larger than the current flowing through the resistor with the least resistance. In other words, total resistance is smaller than the smallest partial resistance.
4. $1/R_T = 1/R_1 + 1/R_2 = (R_1 + R_2)/(R_1 \cdot R2)$
   $R_T = (R_1 \cdot R_2)/(R_1 + R_2)$

Notes

The values for resistance R_1 and R_2 noted in Table 2 deviate considerably from the values printed on the resistors. You may want to use this opportunity to discuss margins of errors.
From the equation $I_T = I_1 + I_2$ we get (based on $I = U/R$):

$$U_T/R_T = U_1/R_1 + U_2/R_2$$

and, based on $U_T = U_1 = U_2$

$$1/R_T = 1/R_1 + 1/R_2.$$

This also confirms the theoretical basis for the results of the experiment.
The terms “equivalent resistance” and “branch resistance” are more comprehensible than the terms “total resistance” and “partial resistance” for parallel circuits. It is recommended that you use these terms especially if they are used in the student textbooks.

Current and Resistance in a Parallel Connection

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Room for notes