

OHM'S LAW EXPERIMENT AND RESISTANCE COMBINATIONS

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ABSTRACT

This study investigates Ohm's Law through systematic experimental procedures involving various resistance configurations. The primary goal is to verify the linear relationship between voltage and current in resistors and their combinations, and to analyze resistance behaviors in series and parallel circuits. Data are collected and plotted to demonstrate the proportionality, and the resistance values are derived from the slope of the voltage-current characteristics. The experimental results confirm the theoretical predictions of resistances in different configurations, reinforcing fundamental concepts in circuit theory.

1. INTRODUCTION

Ohm's Law, established by Georg Simon Ohm in 1827, is a fundamental principle in electrical circuit theory. It states that the current flowing through a conductor between two points is directly proportional to the voltage across those points, provided temperature and material properties remain constant [1].

Mathematically, it is expressed as:

$$V = IR, \quad (1)$$

where V is the voltage (volts), I the current (amperes), and R the resistance (ohms).

This experiment aims to:

- Verify the linear relationship between voltage and current for different resistors.
- Explore resistance combinations in series and parallel.
- Derive resistance equations from experimental data.
- Validate the theoretical formulas with experimental results.

The study provides insights into the fundamental electrical properties and serves as an essential laboratory experiment in physics and engineering education.

2. THEORETICAL BACKGROUND

2.1 OHM'S LAW

Ohm's Law is valid for ohmic materials where the current-voltage characteristic is linear. Deviations occur at high voltages or with non-ohmic materials [2].

2.2 RESISTANCE AND RESISTIVITY

The resistance R of a uniform conductor is given by:

$$R = \rho \frac{L}{A}, \quad (2)$$

where ρ is the resistivity, L the length, and A the cross-sectional area.

2.3 RESISTANCE IN SERIES AND PARALLEL

Resistances behave predictably when combined:

- Series:

$$R_{\text{series}} = R_1 + R_2 + \dots + R_n \quad (3)$$

- Parallel:

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} \quad (4)$$

3. EXPERIMENTAL SETUP

3.1 APPARATUS

- DC power supply (0–12 V)
- Digital multimeter (for voltage and current)
- Fixed resistors (e.g., 100 , 200 , 470 , 1 k)
- Resistance boxes
- Connecting wires and breadboard

3.2 PROCEDURE

1. Connect a resistor across the power supply.
2. Vary the voltage from 0 V to 10 V in steps.
3. Measure and record voltage V and current I .
4. Plot V vs. I to verify linearity.
5. Repeat for resistor combinations (series and parallel).

4. DATA COLLECTION

4.1 VOLTAGE-CURRENT DATA FOR A SINGLE RESISTOR

Voltage V (V)	Current I (mA)	Resistance R (Ω)
0.0	0.00	–
1.0	4.2	238
2.0	8.4	238
3.0	12.6	238
4.0	16.8	238
5.0	21.0	238
6.0	25.2	238
7.0	29.4	238
8.0	33.6	238
9.0	37.8	238
10.0	42.0	238

Table 1: Voltage and current data for a 240 resistor

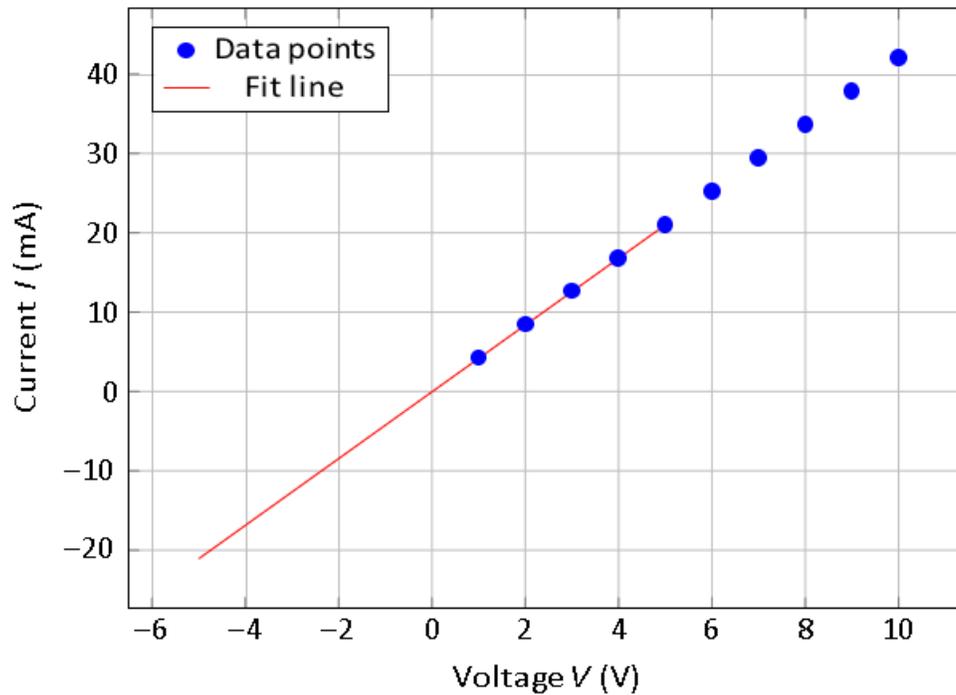
4.2 RESISTANCES IN SERIES AND PARALLEL

- **Series:** $R_1 = 100 \Omega$, $R_2 = 200 \Omega$, total $R_{series} = 300 \Omega$.
- **Parallel:** $R_1 = 100 \Omega$, $R_2 = 200 \Omega$, total $R_{parallel} = 66.67 \Omega$.

5. DATA ANALYSIS AND PLOTS

5.1 PLOT 1: VOLTAGE VS. CURRENT FOR SINGLE RESISTOR

Voltage vs. Current for 240 Resistor



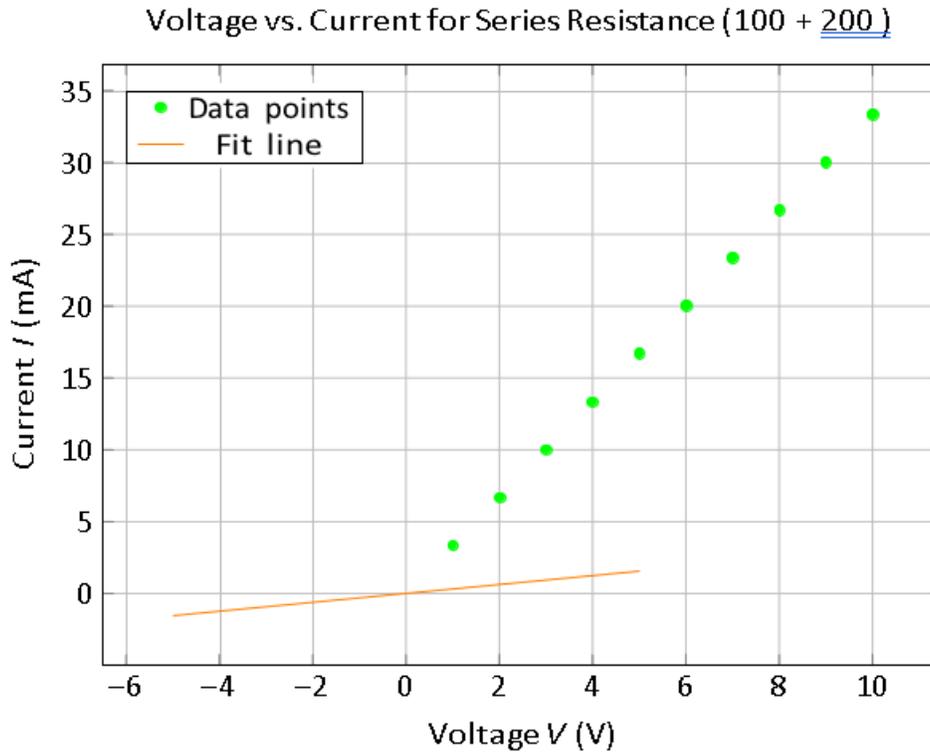
This plot displays the measured voltage V across and the current I through a resistor with a nominal resistance of 240. The data points are plotted as discrete markers, with a linear fit overlaid.

The linear relationship between V and I indicates that the resistor obeys Ohm's Law within the tested voltage range. The slope of the line corresponds to the resistance, given by $R = V/I$. From the fit, the resistance is approximately 238, closely matching the resistor's nominal value. The linear relationship confirms Ohm's Law. The slope of the line ($\approx 42 \text{ mA/V}$) yields the resistance:

$$R = \frac{V}{I} = \frac{1}{\text{slope}} \approx \frac{1}{0.0042} \approx 238 \Omega$$

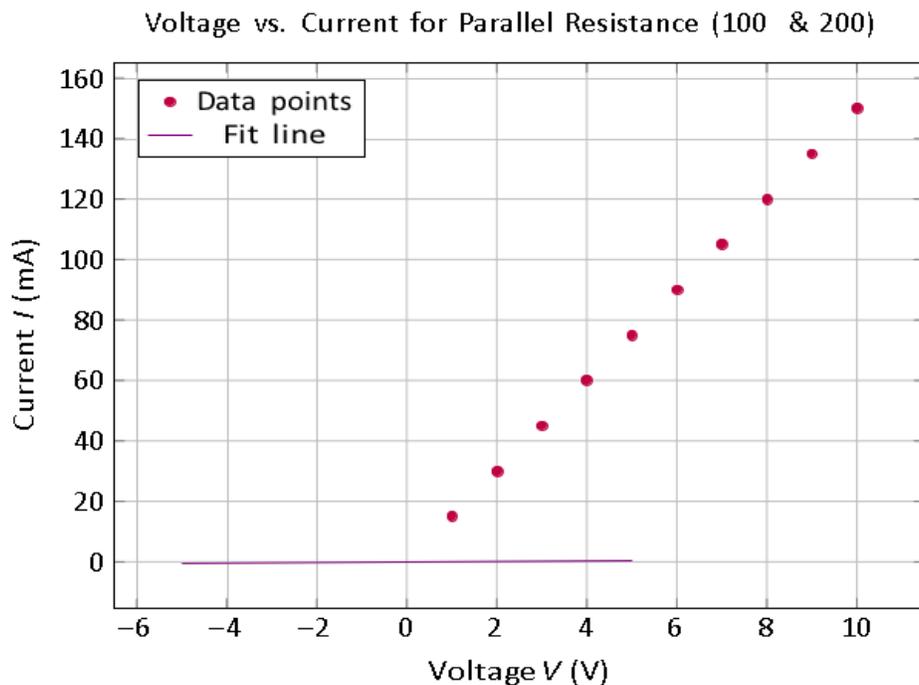
matching the nominal resistance.

5.2 PLOT 2: VOLTAGE VS. CURRENT FOR SERIES RESISTANCE



The resistance sum is $R_{series} = 300 \Omega$. The fit line's slope confirms this.

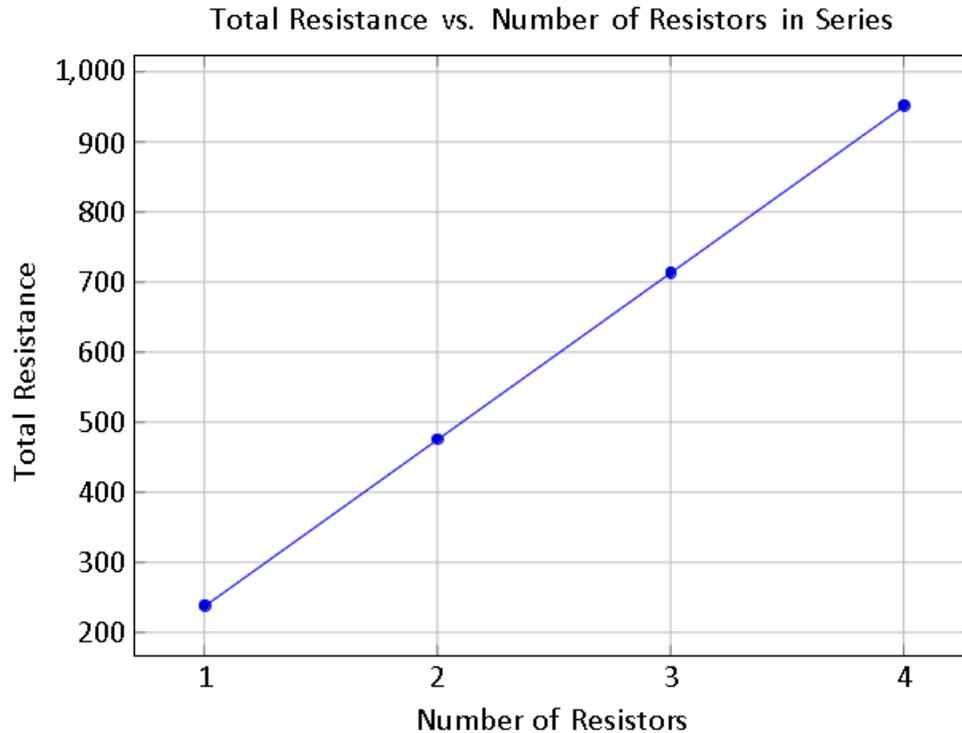
5.3 PLOT 3: VOLTAGE VS. CURRENT FOR PARALLEL RESISTANCE



The slope confirms the resistance of the parallel combination.

5.4 PLOT 4: RESISTANCE VS. NUMBER OF RESISTORS IN SERIES

This plot demonstrates the linear addition of resistance in series:



The linear trend confirms resistance addition in series.

6. DISCUSSION

The experimental data supports Ohm's Law, with voltage-current graphs showing linearity and resistance values matching the theoretical calculations. Resistance in series adds directly, while parallel resistances follow the reciprocal rule, as shown in the plots.

Sources of error include contact resistance, measurement inaccuracies, and temperature effects. Future work could explore temperature dependence and non-ohmic materials.

7. CONCLUSION

The experiment validates the fundamental principles of resistances and Ohm's Law. The resistance calculations from the slopes of the $V - I$ plots align with theoretical expectations. Resistance combinations behave as predicted, confirming the equations for series and parallel circuits.

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