Configurations of Resistors

Safety and Equipment

- Multimeter with probes or banana leads.
- Two of 50Ω and one of 100Ω resistors
- 5 connecting wires with double alligator clips

Introduction

There are two basic ways to connect resistors in an electrical circuit: in parallel and in series.

In series, two resistors have only one point of connection and form one continuous path for the current. Therefore, the same current flows through each resistor. Because there is only one passage for the current in series configuration, the resistances of the individual resistors sum up into the total resistance of the configuration.

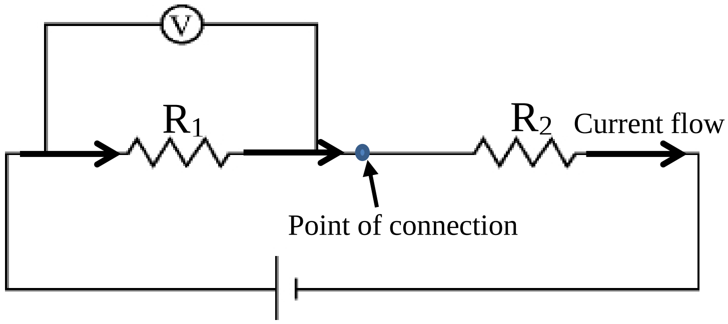

Figure 1. Resistors in series configuration. The voltmeter in this figure measures the voltage across R_1 only.

In series, the potential difference across an individual resistor depends on the value of the resistance: the greater the resistance the greater the voltage measured across that resistor. Each resistor participating in series configuration drops the potential. The individual voltage drops should add up to the total voltage of the entire configuration.

$$V_{\text{series}} = V_1 + V_2 + \cdots$$

In parallel, each resistor is connected to the others at two points. The result is that the same potential difference exists across each resistor. Each resistor then forms a separate pathway for the current. Therefore, there are multiple passages for the current in parallel configuration, and different current flows through each resistor.

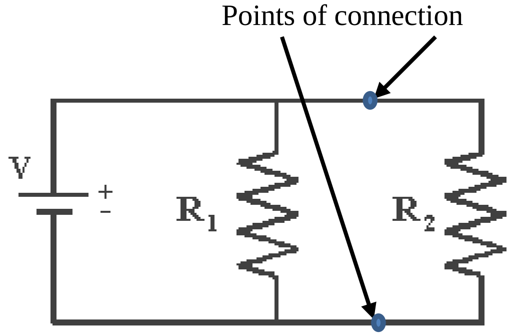

Figure 2. Resistors in parallel configuration. Note that the resistors are connected to each other at two points.

Since the potential drop across every resistor in parallel configuration is the same, the current flowing through an individual resistor depends on the value of the resistance: the greater the resistance the smaller the current measured through that resistor. Because there are multiple passages for the current in parallel configuration, the currents trough the individual resistors should add up into the total current flowing in and out of the configuration.

$$I_{\text{parallel}} = I_1 + I_2 + \cdots$$

Objective:

- *To investigate the current and voltage distribution in basic configurations of resistors.*

Part#1 Series Configuration of Resistors

1. Connect two resistors, $R_1 = 100\Omega$ and $R_2 = 50\Omega$, in series and use Multimeter set as an Ohmmeter to measure the equivalent resistance of the configuration (refer to Lab #2 Part 1).
2. Compare the measured value with the calculated value. The series equivalent resistance is calculated by: $R_{eq} = R_1 + R_2$

Description	Value
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% Diff	

Table 1.1. Series resistance of R_1 and R_2, both measured and calculated.

3. Open the "DC Power Supply Set Up" file from the Blackboard (Lab #3 folder).
4. Construct a circuit that consists of two resistors, 50Ω and 100Ω, connected in series to the power supply.
5. Set up the Multimeter as a Voltmeter. Measure the terminal voltage of the loaded circuit and the voltage across each resistor (refer to Lab #2 part 3).
6. Set up the Multimeter as an Ammeter. Measure the current through each resistor and the current through the power supply (refer to Lab #2 part 2).

Device	Voltage Across (V)	Current Through (A)
Power Supply		
R_1(100Ω)		
R_2(50Ω)		

Table 1.2. Voltages and currents in the series circuit consisting of just R_1 and R_2.

7. State the mathematical relationship between the currents (Hint: I_{ps} = …) and the relationship between the potential differences (Hint: V_{ps} = …).

8. Compare the ratio of the voltages across the resistors (V_1/V_2) with the ratio of the resistances (R_1/R_2).
9. Predict how the current and voltage distribution will change if another 50Ω resistor is added in series to the others. Check your prediction and report the new values of the current and voltage.

Device	Predicted Voltage (V)	Predicted Current (A)	Measured Voltage (V)	Measured Current (A)
Power Supply				
R_1(100Ω)				
R_2(50Ω)				
R_3(50Ω)				

Table 1.3. Predicted and measured voltages and currents in the series circuit consisting of R_1, R_2, and R_3.

Part #2 Parallel Configuration of Resistors

1. Connect two resistors, $R_1 = 100\Omega$ and $R_2 = 50\Omega$, in parallel and measure the equivalent resistance of the configuration. Compare the measured value with the calculated value. The parallel equivalent resistance is calculated by: $R_{eq} = (R_1^{-1} + R_2^{-1})^{-1}$

Description	Value
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% Diff	

Table 2.1. Parallel resistance of R_1 and R_2, both measured and calculated.

2. Construct a circuit that consists of two resistors, R_1 and R_2, connected in parallel with the power supply.
3. Set up the Multimeter as a Voltmeter. Measure the voltage across the power supply and each resistor.
4. Set up the Multimeter as an Ammeter. Measure the current through each resistor and through the power supply. (Note: measuring the current through R_1 from Figure 2 is tricky; ask the lab instructor to check your settings)

Device	Voltage Across (V)	Current Through (A)
Power Supply		
R_1(100Ω)		
R_2(50Ω)		

Table 2.2. Voltages and currents in the parallel circuit consisting of just R_1 and R_2.

5. State the mathematical relationship between the currents (Hint: I_{ps} =…); state the mathematical relationship between the potential differences (Hint: V_{ps} =…).
6. Compare the ratio of the current through the resistors (I_1/I_2) with the ratio of the resistances (R_1/R_2).
7. Predict how the current and voltage distribution changes if another 50 Ω resistor is added in parallel to the circuit. Check your prediction and report the new values of the current and voltage.

Device	Predicted Voltage (V)	Predicted Current (A)	Measured Voltage (V)	Measured Current (A)
Power Supply				
R_1(100Ω)				
R_2(50Ω)				
R_3(50Ω)				

Table 2.3. Predicted and measured voltages and currents in the parallel circuit consisting of R_1, R_2, and R_3.

Part #3 Mix-Configuration of Resistors

1. Connect two resistors, R_1 (100 Ω) and R_2 (50 Ω), in parallel and add R_3 (50 Ω) in series to the first configuration. Calculate the expected resistance. Measure the equivalent resistance of the mix-configuration. (Hint: Since R_1 and R_2 are in parallel, use the parallel rule to find their combined resistance. Then since R_3 is in series with the R_1/R_2 pair, simply add R_3 for the overall result.)

Description	Value
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% Diff	

Table 3.1. Mix-configuration resistance, both measured and calculated.

2. Connect your combination to the power supply (red terminal of the power supply should be connected to R_1/R_2 junction and black terminal of the power supply should be connected to R_3).
3. Measure the current through each resistor and through the power supply; then measure the terminal voltage and the voltage across each resistor.

Device	Voltage Across (V)	Current Through (A)
Power Supply		
R_1(100Ω)		
R_2(50Ω)		
R_3(50Ω)		

Table 3.2. Voltages and currents in the mix-configuration circuit consisting of just R_1, R_2 and R_3.

4. Mathematically state the relationship between the currents (Hint: I_{ps} =…); mathematically state the relationship between the potential differences (Hint: V_{ps} =…).
5. Compare the ratio of the current through the resistors (I_1/I_2) with the ratio of the resistances (R_1/R_2).

Requirements for the Report:

The report must contain a **Header** at the top (Title of Lab, Authors, and Date)

Abstract Section must contain the following in paragraph form:

- Brief Introduction that includes objectives and basic theory of the lab. Include:
    - How one could tell if elements of a unit connected in series or in parallel?
    - How a type of connection affects the resistance of the unit?
    - What makes the current flow different in series and parallel configurations?
    - What makes the voltage distribution different in series and parallel configurations?
- Methodology describing broadly what was done, using what tools, and what was measured/recorded.
- Data Summary that describes the importance of each Table. Highlight the key values from each Table, and use those values to back up your conclusions.
    - ***Series**:* How does measured equivalent resistance of series circuit compare with calculated equivalent resistance? What is mathematical relationship for current in a series circuit? Voltage? How does the ratio of voltages (V_1/V_2) compare to ratio of resistances (R_1/R_2)? If a third resistor were added in series to the other resistors, what would be the effect on current? Voltage? Do the measured values of current and voltage for a series circuit with three resistors match your predictions?
    - ***Parallel***: How does measured equivalent resistance of parallel circuit compare with calculated equivalent resistance? What is mathematical relationship for current in a parallel circuit? Voltage? How does the ratio of currents (I_1/I_2) compare to ratio of resistances (R_1/R_2)? If a third resistor were added in parallel to the other resistors, what would be the effect on voltage? Current? Do the measured values of current and voltage for a parallel circuit with three resistors match your predictions?
    - ***Mixed:*** How does measured equivalent resistance of mixed circuit compare with calculated equivalent resistance? What is mathematical relationship for current in a mixed circuit? Voltage? How does the ratio of currents (I_1/I_2) compare to ratio of resistances (R_1/R_2)?
- The lab manual contains several imperatives throughout that will guide you with the conclusions for all of the tables. **Always incorporate the questions and/or imperatives from the lab manual**.

Data Section must contain the following:
[Each table should be labeled and captioned based on purpose and circuit components]

- 8 Tables