

A Power Supply Is Connected To A 59 Ohm Resistor And A 53 Ohm Resistor In Series. The Total Current Is

A Power Supply Is Connected To A 59 Ohm Resistor And A 53 Ohm Resistor In Series. The Total Current Is a fundamental concept in electrical circuits, illustrating the principles of series resistor configurations and Ohm's Law. Understanding how to determine the total current flowing through such a circuit is essential for students, engineers, and hobbyists working with electronic components. This article provides an in-depth explanation of how to analyze a series resistor circuit, including the calculations involved, practical applications, and tips for troubleshooting.

Understanding Series Resistor Circuits

What Is a Series Circuit?

A series circuit is one where components are connected end-to-end in a single path for current flow. In such configurations, the same current flows through all components, but the voltage across each component may differ. Series circuits are commonly used in various electronic devices, power distribution systems, and educational demonstrations.

Characteristics of Series Resistors

- Same Current Through All Resistors: The current passing through each resistor is identical.
- Voltage Division: The total voltage supplied by the power source divides across the resistors proportionally to their resistance.
- Total Resistance: The combined resistance of resistors in series is the sum of individual resistances.

Calculating Total Resistance in Series

Sum of Resistor Values

When resistors are connected in series, the total resistance (R_{total}) is calculated as:

$$R_{\text{total}} = R_1 + R_2 + \dots + R_n$$

For the given circuit with two resistors:

$$R_{\text{total}} = 59\,\Omega + 53\,\Omega = 112\,\Omega$$

This total resistance determines how the circuit behaves under a given voltage.

Applying Ohm's Law to Find Total Current

Ohm's Law Overview

Ohm's Law states that:

$$V = I \times R$$

where:

- V is the voltage across the resistor,
- I is the current through the resistor,
- R is the resistance.

Rearranged to solve for current:

$$I = \frac{V}{R}$$

Determining the Power Supply Voltage

To find the total current, the voltage of the power supply must be known. Suppose the power supply provides a voltage V_s . The total current in the circuit is then:

$$I_{\text{total}} = \frac{V_s}{R_{\text{total}}}$$

Without knowing V_s , the total current cannot be directly calculated. For illustrative purposes, assume a supply voltage.

Calculating Total Current for Different Power Supply Voltages

Example: Power Supply Voltage of 12V

If the power supply provides 12 volts:

$$I_{\text{total}} = \frac{12\text{ V}}{112\text{ }\Omega} \approx 0.107\text{ A} \quad (\text{or } 107\text{ mA})$$

Example: Power Supply Voltage of 24V

For a 24V supply:

$$I_{\text{total}} = \frac{24\text{ V}}{112\text{ }\Omega} \approx 0.214\text{ A} \quad (\text{or } 214\text{ mA})$$

Example: Power Supply Voltage of 48V

For a 48V source:

$$I_{\text{total}} = \frac{48\text{ V}}{112\text{ }\Omega} \approx 0.429\text{ A} \quad (\text{or } 429\text{ mA})$$

Note: The actual total current depends linearly on the supply voltage.

Understanding Voltage Distribution Across Resistors

Voltage Divider Concept

In a series resistor circuit, the voltage across each resistor is proportional to its resistance:

$$V_{\{R\}} = I \times R$$

Alternatively, knowing the total voltage:

$$V_{\{R\}} = V_{\{s\}} \times \frac{R_{\{R\}}}{R_{\text{total}}}$$

Calculating Individual Voltages

Suppose the supply voltage (V_s) is 12V:

- Voltage across the 59Ω resistor:

$$V_{59} = 12\text{ V} \times \frac{59\text{ }\Omega}{112\text{ }\Omega} \approx 6.3\text{ V}$$

- Voltage across the 53Ω resistor:

$$V_{53} = 12\text{ V} \times \frac{53\text{ }\Omega}{112\text{ }\Omega} \approx 5.7\text{ V}$$

The sum of these voltages equals the total supply voltage, confirming the voltage division principle.

Practical Applications and Considerations

Designing Voltage Dividers

Voltage dividers are commonly used in applications where a specific voltage is needed from a higher voltage source, such as sensor power supplies or biasing circuits. Resistors in series form the core of voltage divider circuits.

Power Dissipation in Resistors

Each resistor dissipates power, which must be within its rated capacity:

$$P = I^2 \times R$$

For the example with a 12V supply and total resistance of 112Ω:

$$P_R = (0.107\text{ A})^2 \times R$$

- Power across 59Ω resistor:

$$P_{59} = (0.107)^2 \times 59 \approx 0.68\text{ W}$$

- Power across 53Ω resistor:

$$P_{53} = (0.107)^2 \times 53 \approx 0.6, \text{ W}$$

Ensure resistors can handle this power; otherwise, they may overheat.

Impact of Resistance Values on Circuit Behavior

- Increasing resistance decreases current.
- Lower resistance results in higher current and power dissipation.
- Component ratings must be considered to prevent damage.

Troubleshooting Common Issues

Unexpected Current Readings

- Verify the power supply voltage.
- Check resistor values with a multimeter.
- Inspect for open circuits or short circuits.

Overheating Resistors

- Ensure resistors are rated for the calculated power dissipation.
- Use resistors with higher power ratings if necessary.
- Confirm that connections are secure and not causing unintended resistance.

Voltage Measurement Problems

- Use proper measurement techniques with a multimeter.
- Confirm that probes contact the correct points.
- Be cautious of parallel paths that may affect voltage readings.

Conclusion

Analyzing a circuit where a power supply is connected to a 59 Ohm resistor and a 53 Ohm resistor in series involves calculating the total resistance, applying Ohm's Law, and understanding voltage distribution. The total current depends on the supply voltage and the combined resistance. By understanding these principles, engineers and hobbyists can design effective circuits, troubleshoot issues, and optimize power usage. Always remember to consider resistor power ratings and ensure proper measurement techniques to maintain circuit safety and performance.

In summary:

- Total resistance: 112Ω

- Total current: $I_{\text{total}} = \frac{V_{\text{s}}}{112\, \Omega}$
- Voltage across each resistor: proportional to resistance
- Power dissipation: must be within resistor ratings

By mastering these concepts, you can confidently analyze and build series resistor circuits for various applications.

Frequently Asked Questions

What is the total resistance when a 59 Ohm resistor and a 53 Ohm resistor are connected in series?

The total resistance is the sum of both resistances: $59\, \Omega + 53\, \Omega = 112\, \Omega$.

If a power supply provides 24V, what is the current flowing through a series circuit with resistors of 59 Ohm and 53 Ohm?

Using Ohm's law, current $I = V / R_{\text{total}} = 24\text{V} / 112\, \Omega \approx 0.214\, \text{A}$.

How do you calculate the total current in a series circuit with known resistances and voltage?

First, find the total resistance by adding all resistors in series, then apply Ohm's law: $I = V / R_{\text{total}}$.

What is the significance of connecting resistors in series in a circuit?

Connecting resistors in series increases the total resistance, which reduces the overall current for a given voltage.

Can the total current in the series circuit be calculated without knowing the voltage of the power supply?

No, the total current depends on both the total resistance and the voltage supplied; without voltage, current cannot be determined.

What would be the current if the power supply voltage is 12V for the given resistors?

Total resistance is $112\, \Omega$; thus, $I = 12\text{V} / 112\, \Omega \approx 0.107\, \text{A}$.

If the resistors are in series, how is the voltage distributed across each resistor?

The voltage divides proportionally to each resistor's resistance: $V_1 = (R_1 / R_{\text{total}}) V$ and $V_2 = (R_2 / R_{\text{total}}) V$.

What is the purpose of analyzing the total current in a series resistor circuit?

To determine the current flow, power consumption, and ensure circuit components operate within safe limits.

How does increasing one resistor in series affect the total current in the circuit?

Increasing a resistor's value increases total resistance, which decreases the total current for a given voltage.

What are common applications of series resistor circuits like the one described?

They are used in voltage dividers, current limiting, and LED brightness control in various electronic devices.

Additional Resources

[Power Supply Connected to a 59 Ohm and a 53 Ohm Resistor in Series: An In-Depth Analysis of Total Current Calculation](#)

Understanding the behavior of electrical circuits is fundamental to both theoretical physics and practical engineering. When a power supply is connected to resistors in series, the total current flowing through the circuit is dictated by Ohm's Law and the principles of series circuits. In this comprehensive review, we explore every facet of such a configuration, focusing on calculating the total current, analyzing the implications, and understanding the underlying physics.

Introduction to Series Circuits and Power Supplies

The Basics of Series Connection

A series circuit involves connecting electronic components end-to-end, forming a single path for current flow. When resistors are connected in series:

- Same Current Flows Through All Components: The current through each resistor is equal.
- Total Resistance is the Sum of Individual Resistances: The total resistance increases linearly with the addition of resistors.

Mathematically, for resistors $(R_1, R_2, \dots, R_n)$:

$$R_{\text{total}} = R_1 + R_2 + \dots + R_n$$

The Role of the Power Supply

The power supply, characterized by its voltage (V) , provides the electromotive force (EMF) necessary to drive current through the circuit. Its voltage, combined with the total resistance, determines the current flow based on Ohm's Law:

$$I = \frac{V}{R_{\text{total}}}$$

Key Point: The power supply must supply sufficient voltage to overcome the total resistance and produce the desired current.

Understanding the Resistor Values and Their Impact

Given Resistor Values

In our specific scenario:

- Resistor 1: $(R_1 = 59\, \Omega)$
- Resistor 2: $(R_2 = 53\, \Omega)$

These resistors, being relatively close in value, contribute significantly to the total resistance. Their sum:

$$R_{\text{total}} = 59\, \Omega + 53\, \Omega = 112\, \Omega$$

This total resistance plays a crucial role in the current calculation.

Effect of Resistance on Current

From Ohm's Law:

$$I = \frac{V}{R_{\text{total}}}$$

- Higher resistance values result in lower current for a given voltage.
- Lower resistance values allow for higher current.

Understanding how these resistances influence the current helps in designing circuits with desired current levels, ensuring components operate within their specified limits.

Calculating the Total Current in the Circuit

Determining the Power Supply Voltage

The critical missing piece in the initial problem statement is the voltage of the power supply. Without knowing (V) , we cannot compute the exact current. However, the calculation process remains the same once the voltage is known.

Suppose the power supply voltage is (V) volts, then:

$$I_{\text{total}} = \frac{V}{R_{\text{total}}} = \frac{V}{112\, \Omega}$$

Example Calculations:

- If $(V = 12\, V)$:

$$I_{\text{total}} = \frac{12\, V}{112\, \Omega} \approx 0.107\, A$$

- If $(V = 24\, V)$:

$$I_{\text{total}} = \frac{24\, V}{112\, \Omega} \approx 0.214\, A$$

- If $(V = 5\, V)$:

$$I_{\text{total}} = \frac{5\, V}{112\, \Omega} \approx 0.045\, A$$

These examples illustrate the linear relationship between voltage and current in a simple series circuit.

Generalized Formula and Its Significance

The generalized formula is:

$$\boxed{I_{\text{total}} = \frac{V}{R_1 + R_2}}$$

which emphasizes the importance of knowing the supply voltage for any meaningful current calculation.

Implications of the Series Connection and Total Resistance

Voltage Division Across Resistors

In a series circuit, the total supply voltage divides among the resistors proportionally to their resistances:

$$V_{R_1} = I \times R_1$$

$$V_{R_2} = I \times R_2$$

and

$$V = V_{R_1} + V_{R_2}$$

This voltage division is fundamental in designing voltage dividers and other voltage-dependent circuits.

Example:

If $(V = 12\text{ V})$ and $(I \approx 0.107\text{ A})$:

$$V_{R_1} = 0.107\text{ A} \times 59\text{ }\Omega \approx 6.31\text{ V}$$

$$V_{R_2} = 0.107\text{ A} \times 53\text{ }\Omega \approx 5.66\text{ V}$$

Total check:

$$6.31\text{ V} + 5.66\text{ V} \approx 11.97\text{ V} \approx 12\text{ V}$$

which shows the voltage division principle in action, with small rounding errors.

Power Dissipation in Resistors

Resistors dissipate electrical energy as heat, proportional to the square of the current and resistance:

$$P = I^2 \times R$$

or

$$P = \frac{V^2}{R}$$

Calculations:

- For resistor $(R_1 = 59\, \Omega)$:

$$P_{R_1} = I^2 \times 59\, \Omega$$

- For resistor $(R_2 = 53\, \Omega)$:

$$P_{R_2} = I^2 \times 53\, \Omega$$

Using the example current of 0.107 A:

$$P_{R_1} \approx (0.107)^2 \times 59 \approx 0.676\, W$$

$$P_{R_2} \approx (0.107)^2 \times 53 \approx 0.603\, W$$

This power dissipation analysis helps ensure resistors are rated appropriately to avoid overheating.

Practical Considerations and Real-World Factors

Resistor Tolerance and Variability

Resistors are not perfectly precise; their actual resistance can vary within a tolerance range (commonly $\pm 5\%$). This variation affects the total resistance and thus the current calculation.

Impact:

- Slight deviations in resistance lead to variations in current.
- For critical applications, high-precision resistors with lower tolerance are preferred.

Temperature Effects

Resistor resistance varies with temperature:

- Positive Temperature Coefficient: Resistance increases with temperature.
- Negative Temperature Coefficient: Resistance decreases with temperature.

In circuits where resistors heat up significantly, the actual resistance—and hence the current—may differ from initial calculations.

Power Supply Limitations

The power supply must be capable of delivering the calculated current without voltage drops or overheating. Overloading the supply can cause voltage sag, affecting circuit operation.

Extending the Analysis: Series-Parallel Combinations and Complex Circuits

While the initial problem involves a simple series connection, real-world circuits often combine series and parallel elements. Understanding the principles here provides a foundation to analyze more complex networks.

- Parallel Resistors: Total resistance decreases, affecting current distribution.
- Series-Parallel Circuits: Require careful reduction to equivalent resistances before applying Ohm's Law.

Educational and Practical Significance

Understanding the relationship between resistor values, supply voltage, and resulting current is fundamental in circuit design. Whether designing a simple voltage divider or complex electronic systems, these principles:

- Enable precise control of current and voltage.
- Help in power management and heat dissipation considerations.
- Aid in troubleshooting circuit issues related to incorrect resistor values or supply voltages.

Concluding Remarks

In summary, connecting a power supply to a series combination of a 59 Ohm and a 53 Ohm resistor results in a total resistance of 112 Ohms. The total current flowing through this circuit depends directly on the supply voltage, governed by Ohm's Law:

$$I_{\text{total}} = \frac{V}{112\, \Omega}$$

Without the specific voltage value, the exact current cannot be computed. However, the methodology remains straightforward: knowing the voltage allows you to determine the current, voltage drops across each resistor, and power dissipation.

This analysis underscores the importance of understanding resistor values, series circuit principles, and the properties of power supplies in both academic and practical contexts. Mastery of these fundamentals enables engineers and hobbyists alike to design, analyze, and troubleshoot circuits effectively, ensuring safe and efficient operation.

In essence, the total current in a series resistor circuit is a direct reflection of the supply voltage and the sum of resistances—fundamental principles that underpin all electronic circuit analysis.

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