

A 16.2 Resistor, 10.9 Resistor, And A 4.9 Resistor Are Connected In Series With An Emf Source. The Current

A 16.2 Resistor, 10.9 Resistor, And A 4.9 Resistor Are Connected In Series With An Emf Source. The Current in a series circuit involving resistors and an emf (electromotive force) source is a fundamental concept in electrical engineering and physics. Understanding how the current behaves when resistors are connected in series helps in designing circuits, troubleshooting electrical systems, and analyzing electrical properties. This article explores the principles behind such a configuration, including how to determine the current, the total resistance, and related calculations, providing a comprehensive guide for students, professionals, and enthusiasts alike.

Understanding Series Circuits and Resistors

What Is a Series Circuit?

A series circuit is a type of electrical circuit where components are connected end-to-end in a single path for the current to flow. In such circuits:

- The same current passes through each component.
- The total voltage across the circuit is the sum of the voltages across individual components.
- The total resistance is the sum of individual resistances.

This configuration contrasts with parallel circuits, where components are connected across the same voltage source, and the current divides among multiple paths.

The Role of Resistors in a Series Circuit

Resistors are passive electrical components that oppose the flow of current, characterized by their resistance value (measured in ohms, Ω). In a series connection:

- Each resistor adds to the total resistance of the circuit.
- The overall resistance influences the total current supplied by the emf

source.

- The voltage drop across each resistor depends on its resistance and the current flowing through the circuit.

Calculating Total Resistance in a Series Connection

Given resistors of $16.2\ \Omega$, $10.9\ \Omega$, and $4.9\ \Omega$ connected in series, the total resistance (R_{total}) is straightforward to compute:

$$R_{\text{total}} = R_1 + R_2 + R_3$$

where:

- $R_1 = 16.2\ \Omega$
- $R_2 = 10.9\ \Omega$
- $R_3 = 4.9\ \Omega$

Calculating:

$$R_{\text{total}} = 16.2 + 10.9 + 4.9 = 32.0\ \Omega$$

This total resistance determines how much the circuit resists the flow of current supplied by the emf source.

Determining the Current in the Series Circuit

Understanding Ohm's Law

Ohm's Law is fundamental in calculating current in electrical circuits:

$$I = V / R$$

where:

- I = current in amperes (A)
- V = emf (voltage) in volts (V)
- R = total resistance in ohms (Ω)

To find the current, the emf source's voltage is essential.

Applying the Formula with an emf Source

Suppose the emf source provides a voltage of V volts. The current flowing through the series circuit is:

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

For example, if the emf source supplies 12 volts:

$$I = 12 \text{ V} / 32.0 \text{ } \Omega = 0.375 \text{ A}$$

This means a current of 0.375 amperes flows uniformly through all three resistors.

Voltage Drops Across Resistors

Calculating Voltage Drop Across Each Resistor

The voltage drop across each resistor can be calculated using Ohm's Law:

$$V_R = I \times R$$

Since the current is the same throughout the series circuit, the voltage drops are:

- $V_1 = I \times R_1 = 0.375 \text{ A} \times 16.2 \text{ } \Omega = 6.075 \text{ V}$
- $V_2 = I \times R_2 = 0.375 \text{ A} \times 10.9 \text{ } \Omega = 4.088 \text{ V}$
- $V_3 = I \times R_3 = 0.375 \text{ A} \times 4.9 \text{ } \Omega = 1.838 \text{ V}$

The sum of these voltage drops equals the emf:

$$6.075 + 4.088 + 1.838 \approx 12 \text{ V}$$

which confirms the consistency of calculations.

Impacts of Resistor Values on Circuit Behavior

How Resistance Affects Current

Higher resistance values result in lower current for a given emf. Conversely, lower resistance increases the current flow. In our example:

- Increasing R_1 or R_2 will decrease the overall current.
- Decreasing any resistor will increase the current proportionally.

Power Dissipation in Resistors

Resistors convert electrical energy into heat, and power dissipation can be calculated as:

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

For each resistor:

- Power in R_1 : $P_1 = (0.375)^2 \times 16.2 \approx 2.28 \text{ W}$
- Power in R_2 : $P_2 = (0.375)^2 \times 10.9 \approx 1.53 \text{ W}$
- Power in R_3 : $P_3 = (0.375)^2 \times 4.9 \approx 0.69 \text{ W}$

These values are crucial for selecting resistors with appropriate power ratings.

Practical Applications and Considerations

Designing Circuits with Multiple Resistors

Understanding the behavior of resistors in series allows engineers to:

- Control voltage distribution within the circuit.
- Design voltage dividers for specific voltage outputs.
- Manage power dissipation to prevent component failure.

Importance of Accurate Resistance Values

Resistor tolerances can affect current and voltage calculations. Using high-precision resistors ensures circuit performance aligns with theoretical expectations.

Summary and Key Takeaways

- Resistors in series add directly to determine total resistance.
- The same current flows through all resistors in series.
- Using Ohm's Law and the total resistance, the current supplied by the emf source can be calculated.
- Voltage drops across resistors are proportional to their resistance and the current.
- Power dissipation in resistors must be considered for safe operation.

Conclusion

Connecting resistors of $16.2\ \Omega$, $10.9\ \Omega$, and $4.9\ \Omega$ in series with an emf source provides a clear example of fundamental electrical principles. By calculating total resistance, current, voltage drops, and power dissipation, one gains insight into how series circuits function. Whether designing simple voltage dividers or complex electronic systems, understanding these concepts is essential for ensuring circuit reliability, efficiency, and safety. Mastery of these calculations enables engineers and enthusiasts to predict circuit behavior accurately and optimize their designs accordingly.

This comprehensive overview underscores the importance of resistors in series circuits and offers practical guidance for analyzing and applying these principles in real-world scenarios.

Frequently Asked Questions

What is the total resistance when a $16.2\ \Omega$, $10.9\ \Omega$, and $4.9\ \Omega$ resistor are connected in series?

The total resistance is the sum of all resistances: $16.2\ \Omega + 10.9\ \Omega + 4.9\ \Omega = 32\ \Omega$.

How does the current behave in a series circuit with these resistors connected to an emf source?

In a series circuit, the current is the same through all resistors, and it can be calculated using Ohm's law: $I = E / R_{\text{total}}$.

If the emf source provides 12 V, what is the current flowing through the series circuit?

Using Ohm's law: $I = 12 \text{ V} / 32 \text{ } \Omega = 0.375 \text{ A}$.

How can I determine the voltage drop across each resistor in the series circuit?

The voltage drop across each resistor is given by $V = I \times R$, where I is the current and R is the resistor's resistance. For example, across the $16.2 \text{ } \Omega$ resistor: $V = 0.375 \text{ A} \times 16.2 \text{ } \Omega \approx 6.08 \text{ V}$.

What happens to the current if one resistor's resistance increases in this series circuit?

An increase in resistance increases the total resistance, which decreases the overall current according to Ohm's law, $I = E / R_{\text{total}}$.

Can the resistors be considered independent when calculating the total resistance in series?

Yes, in a series connection, resistances add directly, so each resistor acts independently to influence the total resistance.

What are some practical applications of series resistor circuits like this one?

Series resistor circuits are used in voltage dividers, current limiting in LED circuits, and in various sensor and measurement devices to control voltage and current levels.

Additional Resources

A 16.2 Resistor, 10.9 Resistor, And A 4.9 Resistor Are Connected In Series With An Emf Source. The Current

In the realm of electrical circuits, understanding how resistors influence current flow is fundamental. When multiple resistors are connected in series with a source of electromotive force (emf), the total resistance determines how much current will flow through the entire circuit. This scenario, involving resistors of 16.2 ohms, 10.9 ohms, and 4.9 ohms connected in series with an emf source, offers a practical illustration of basic principles in circuit analysis. This article explores the intricate details of such a setup, breaking down the calculations, implications, and real-world applications in a clear, comprehensive manner.

Understanding Series Circuits: The Basics

What Is a Series Connection?

A series circuit is one where components are connected end-to-end in a single path for current to flow. In this configuration:

- The same current flows through all components.
- The total voltage across the series is the sum of voltages across individual components.
- The total resistance is the sum of the individual resistances.

This simplicity makes series circuits ideal for studying fundamental electrical principles. When resistors are connected in series, the total resistance (R_{total}) is given by:

$$R_{\text{total}} = R_1 + R_2 + R_3 + \dots$$

In our case:

$$R_{\text{total}} = 16.2\,\Omega + 10.9\,\Omega + 4.9\,\Omega$$

which we'll analyze further.

Role of the EMF Source

An emf source, such as a battery or power supply, provides the energy needed to drive current through the circuit. The emf (measured in volts) establishes a potential difference that causes electrons to move, overcoming the resistive forces presented by the resistors.

Key points:

- The emf source maintains a constant potential difference.
- The current in the circuit is determined by the emf and the total resistance.

Calculating the Total Resistance

Sum of Resistances

Given resistors:

- $R_1 = 16.2\,\Omega$
- $R_2 = 10.9\,\Omega$
- $R_3 = 4.9\,\Omega$

Total resistance:

$$R_{\text{total}} = 16.2\,\Omega + 10.9\,\Omega + 4.9\,\Omega = 32\,\Omega$$

This total acts as the primary determinant of current flow when the emf is known.

Impact of Resistance on Current

Ohm's Law states:

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

where:

- I is the current (in amperes),
- V is the emf (in volts),
- R is the total resistance (in ohms).

Knowing the emf allows us to compute the current confidently.

Calculating the Circuit Current

Determining the EMF Source Voltage

Suppose the emf source provides a voltage V . To find the current:

$$I = \frac{V}{R_{\text{total}}} = \frac{V}{32\,\Omega}$$

For example, if the emf is 10 volts:

$$I = \frac{10\,\text{V}}{32\,\Omega} \approx 0.3125\,\text{A}$$

Similarly, for 12 volts:

$$I = \frac{12\,\text{V}}{32\,\Omega} \approx 0.375\,\text{A}$$

This straightforward calculation highlights the direct relationship between voltage, resistance, and current.

Understanding Voltage Drops Across Resistors

In a series circuit, each resistor experiences a voltage drop proportional to its resistance:

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

Using the previous current example (assuming 10 V supply):

- Voltage across 16.2 Ω resistor:

$$V_{16.2} = 0.3125 \text{ A} \times 16.2 \text{ } \Omega \approx 5.06 \text{ V}$$

- Voltage across 10.9 Ω resistor:

$$V_{10.9} = 0.3125 \text{ A} \times 10.9 \text{ } \Omega \approx 3.41 \text{ V}$$

- Voltage across 4.9 Ω resistor:

$$V_{4.9} = 0.3125 \text{ A} \times 4.9 \text{ } \Omega \approx 1.53 \text{ V}$$

Sum of voltage drops:

$$5.06 \text{ V} + 3.41 \text{ V} + 1.53 \text{ V} \approx 10 \text{ V}$$

which matches the emf, confirming the conservation of energy in the circuit.

Implications and Practical Relevance

Designing Circuits for Specific Currents

Engineers and hobbyists often design circuits with targeted current levels. By adjusting resistor values or emf sources, they can control current flow precisely. For instance:

- To limit current to a safe level in sensitive electronic components.
- To create voltage dividers for signal processing.

Understanding the interplay between resistances and emf allows for optimized circuit design.

Power Dissipation in Resistors

Resistors convert electrical energy into heat, which must be managed to prevent damage. Power dissipated:

$$P_{R_i} = I^2 \times R_i$$

For the example with 10 V emf:

- Power in 16.2 Ω resistor:

$$P_{16.2} = (0.3125)^2 \times 16.2 \approx 1.59 \text{ W}$$

- Power in 10.9 Ω resistor:

$$P_{10.9} = (0.3125)^2 \times 10.9 \approx 1.07 \text{ W}$$

- Power in 4.9 Ω resistor:

$$P_{4.9} = (0.3125)^2 \times 4.9 \approx 0.48 \text{ W}$$

These calculations guide the selection of resistors with appropriate power ratings.

Real-World Applications and Considerations

Electrical Circuit Design

Series resistor configurations are common in various applications:

- Voltage dividers
- Current limiting circuits
- Series lighting circuits

Designers must consider resistance values, power ratings, and the emf source to ensure safe and efficient operation.

Limitations and Challenges

While series circuits are straightforward, they have limitations:

- If one resistor fails open, the entire circuit stops conducting.
- Voltage drops across resistors can lead to uneven voltage distribution in complex systems.
- Excessive power dissipation can cause overheating.

Therefore, careful planning and testing are essential.

Conclusion: The Power of Simple Circuit Analysis

Connecting resistors in series with an emf source provides a fundamental yet powerful example of core electrical principles—resistance, current, voltage division, and power dissipation. By summing resistances and applying Ohm's Law, engineers and students alike can predict circuit behavior accurately. Whether designing delicate electronic devices or understanding household wiring, the principles illustrated by the 16.2 Ω , 10.9 Ω , and 4.9 Ω resistors in series serve as foundational knowledge, demonstrating how simple components combine to produce predictable and controllable electrical phenomena. As technology advances, these basic concepts remain vital, underscoring the importance of a solid grasp of circuit analysis in the ever-evolving landscape of electronics and electrical engineering.

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