

A P.d. Of 61.5 V Is Applied To A 103.4 K Resistor.Calculate The Current If The Supply Voltage Is Doubled

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Understanding how voltage, resistance, and current interrelate is fundamental in electrical and electronic engineering. In this article, we will analyze a specific scenario: given an initial voltage of 61.5 V applied across a resistor of 103.4 kilo-ohms (k Ω), what will be the current if the supply voltage is doubled? This problem underscores core principles such as Ohm's Law and the effects of voltage changes on current flow. By the end of this piece, you'll understand how to approach such calculations and the significance of these concepts in real-world applications.

Fundamentals of Ohm's Law

Understanding Voltage, Resistance, and Current

Ohm's Law is the cornerstone of electrical circuit analysis. It states that:

- Voltage (V) is directly proportional to the current (I) flowing through a resistor, with resistance (R) being the proportionality constant.
- The mathematical form is: $V = I \times R$

From this relationship, the current can be expressed as:

- $I = V / R$

where:

- I = Current in amperes (A)
- V = Voltage across the resistor in volts (V)
- R = Resistance in ohms (Ω)

Analyzing the Initial Scenario

Given Data

- Initial Voltage, $V_1 = 61.5 \text{ V}$
- Resistance, $R = 103.4 \text{ k}\Omega = 103,400 \text{ }\Omega$

Calculating Initial Current

Applying Ohm's Law:

$$I_1 = V_1 / R$$

Substituting the values:

$$I_1 = 61.5 \text{ V} / 103,400 \text{ }\Omega \approx 0.000595 \text{ A}$$

or approximately 0.595 milliamperes (mA).

This initial current indicates a very low current flow due to the high resistance value, typical in many electronic components and circuits.

Effect of Doubling the Supply Voltage

New Voltage Calculation

If the supply voltage is doubled:

$$V_2 = 2 \times V_1 = 2 \times 61.5 \text{ V} = 123 \text{ V}$$

The resistance remains unchanged at 103.4 k Ω , so the new current, I_2 , can be calculated similarly.

Calculating the New Current

Applying Ohm's Law again:

$$I_2 = V_2 / R = 123 \text{ V} / 103,400 \text{ }\Omega \approx 0.001188 \text{ A}$$

which is approximately 1.188 mA.

This shows that doubling the voltage effectively doubles the current, consistent with Ohm's Law.

Implications and Applications

Understanding Circuit Behavior

The linear relationship between voltage and current in resistive circuits implies that:

1. Doubling the voltage across a resistor doubles the current flow.
2. The resistance remains constant unless temperature or physical properties change.

This predictable behavior allows engineers to design circuits with precise current values by adjusting the voltage supply.

Real-World Significance

Understanding how voltage influences current is crucial in various scenarios:

- Designing power supplies to prevent overcurrent conditions.
- Ensuring components operate within their rated current limits.
- Calculating power dissipation: $P = V \times I$, which is essential for thermal management.

Additional Considerations

Power Dissipation in the Resistor

As the current increases with doubled voltage, the power dissipated in the resistor also changes.

The power dissipated:

$$P = V \times I$$

For the initial:

$$P_1 = V_1 \times I_1 = 61.5 \text{ V} \times 0.000595 \text{ A} \approx 0.0366 \text{ W}$$

For the doubled voltage:

$$P_2 = V_2 \times I_2 = 123 \text{ V} \times 0.001188 \text{ A} \approx 0.146 \text{ W}$$

This indicates that power dissipation increases fourfold when voltage is doubled, emphasizing the need to ensure resistors can handle the increased power to prevent damage.

Voltage and Resistance Limits

While increasing voltage increases current proportionally, practical limits exist:

1. Voltage ratings of components to prevent breakdown.
2. Power ratings of resistors to avoid overheating.
3. Safety standards to prevent electrical hazards.

Always verify component specifications before making such modifications.

Summary and Key Takeaways

- Ohm's Law provides a simple yet powerful tool to analyze resistive circuits, linking voltage, current, and resistance.
- Doubling the supply voltage across a resistor doubles the current, assuming resistance remains constant.
- Power dissipation increases quadratically with voltage, which must be considered in circuit design.
- Ensuring components can handle increased voltage and power is essential for safe and reliable operation.

Practical Applications in Engineering and Electronics

- Circuit Design: Engineers can predict how changes in voltage affect current and power, facilitating safe and efficient circuit development.
- Troubleshooting: Understanding these relationships helps diagnose issues related to overcurrent or overheating.
- Component Selection: Selecting resistors with appropriate power ratings ensures longevity and safety.
- Power Management: Proper calculation of power dissipation guides thermal management strategies.

Conclusion

In the scenario where a 61.5 V potential difference is applied across a 103.4 kΩ resistor, the initial current is approximately 0.595 mA. When the supply voltage is doubled to 123 V, the current correspondingly doubles to about 1.188 mA, demonstrating the linear relationship dictated by Ohm's Law. Such calculations are foundational for designing, analyzing, and troubleshooting electrical circuits, ensuring they operate within safe and efficient parameters. Whether in small electronic devices or large industrial systems, understanding how voltage impacts current and power is essential for engineers and technicians alike.

Remember: Always consider the maximum voltage and power ratings of your components to prevent damage and ensure safety in your electrical projects.

Frequently Asked Questions

What is the initial current flowing through the resistor when a 61.5 V supply is applied?

The initial current is approximately 0.595 mA, calculated as $I = V / R = 61.5 \text{ V} / 103.4 \text{ k}\Omega$.

How does doubling the supply voltage affect the current through the resistor?

Doubling the supply voltage doubles the current, since current is directly proportional to voltage; the new current will be approximately 1.19 mA.

What is the new current when the supply voltage is doubled to 123 V?

The new current will be approximately 1.19 mA, calculated as $I = (2 \times 61.5 \text{ V}) / 103.4 \text{ k}\Omega$.

Why does increasing the supply voltage increase the current in the resistor?

According to Ohm's Law ($I = V / R$), increasing the voltage across a resistor increases the current proportionally, assuming resistance remains constant.

If the resistor's value remains the same, what is the impact on power dissipation when the voltage is doubled?

Power dissipation increases by a factor of four, since $P = V^2 / R$; doubling the voltage quadruples the power.

What precautions should be taken when doubling the supply voltage in such circuits?

Ensure the resistor and other components can handle the increased power and voltage to prevent overheating or damage.

Additional Resources

Analyzing the Impact of Doubling Supply Voltage on Current in a Resistor Circuit

Understanding the behavior of electrical circuits is fundamental to both theoretical physics and practical engineering applications. When a voltage is applied across a resistor, the resulting current is dictated by Ohm's Law—a cornerstone principle in electrical engineering. This article delves into a specific scenario: a resistor subjected to a given voltage, and the subsequent effect on current when the supply voltage is doubled. Through detailed analysis, we will explore calculations, implications, and broader concepts related to circuit behavior under varying voltage conditions.

Introduction to Ohm's Law and Basic Circuit Principles

What is Ohm's Law?

At the heart of electrical circuit analysis lies Ohm's Law, which establishes a direct proportional relationship among voltage (V), current (I), and resistance (R). The law is mathematically expressed as:

$$V = I \times R$$

where:

- V is the voltage across the resistor (measured in volts, V),
- I is the current flowing through the resistor (measured in amperes, A),
- R is the resistance (measured in ohms, Ω).

This fundamental relation allows engineers and physicists to predict how modifications in voltage or resistance influence current flow within an electrical circuit.

Resistive Circuits and Their Significance

Resistive components are ubiquitous in electrical and electronic systems. They serve various purposes—limiting current, dividing voltages, and dissipating energy as heat. The behavior of these components under different voltages is predictable and linear, making them ideal for analytical

purposes.

In our scenario, the resistor's resistance is known and remains constant, simplifying the analysis of how variations in supply voltage affect current.

Given Data and Initial Calculations

Problem Restatement

A resistor with a resistance of 103.4 kΩ (kilo-ohms) is subjected to an initial supply voltage of 61.5 V. The primary goal is to determine the current flowing through the resistor under this initial voltage and then analyze how this current changes when the supply voltage is doubled.

Converting Resistance to Standard Units

Given resistance:

$$R = 103.4 \text{ k}\Omega = 103,400 \text{ }\Omega$$

Since 1 kΩ = 1000 Ω:

$$R = 103.4 \times 1000 \text{ }\Omega = 103,400 \text{ }\Omega$$

Calculating Initial Current

Applying Ohm's Law:

$$I_{\text{initial}} = \frac{V_{\text{initial}}}{R}$$

$$I_{\text{initial}} = \frac{61.5 \text{ V}}{103,400 \text{ }\Omega}$$

Calculating:

$$I_{\text{initial}} \approx 0.000595 \text{ A}$$

or in milliamperes:

$$I_{\text{initial}} \approx 0.595 \text{ mA}$$

This initial current is quite small, typical of high-resistance circuits, and illustrates the direct proportionality between voltage and current.

Effect of Doubling the Supply Voltage

Understanding Voltage Doubling

Doubling the supply voltage means increasing the initial voltage from 61.5 V to 123 V:

$$V_{\text{new}} = 2 \times V_{\text{initial}} = 2 \times 61.5 \text{ V} = 123 \text{ V}$$

Because resistance remains unchanged, the new current can be calculated using Ohm's Law with this doubled voltage.

Calculating the New Current

Applying Ohm's Law again:

$$I_{\text{new}} = \frac{V_{\text{new}}}{R}$$

$$I_{\text{new}} = \frac{123 \text{ V}}{103,400 \text{ } \Omega}$$

Calculating:

$$I_{\text{new}} \approx 0.00119 \text{ A}$$

or approximately:

$$I_{\text{new}} \approx 1.19 \text{ mA}$$

This result confirms that current doubles as voltage doubles, consistent with the linear behavior predicted by Ohm's Law.

Analytical Insights and Broader Implications

The Direct Proportionality Between Voltage and Current

The calculations reaffirm a fundamental principle: in purely resistive circuits, current is directly proportional to the applied voltage. When resistance is constant:

$$I \propto V$$

Doubling the voltage results in exactly double the current, illustrating the linearity and predictability of resistive elements.

Implications for Circuit Design and Safety

In practical scenarios, doubling the supply voltage can have significant consequences:

- Thermal Effects: Increased current leads to higher power dissipation in the resistor, calculated as:

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

or

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

For the initial voltage:

$$P_{\text{initial}} = \frac{(61.5)^2}{103,400} \approx 0.0366 \text{ W}$$

For the doubled voltage:

$$P_{\text{new}} = \frac{(123)^2}{103,400} \approx 0.146 \text{ W}$$

The power dissipated increases fourfold, which could risk overheating if the resistor isn't rated accordingly.

- Component Ratings: Resistors have maximum power ratings. Exceeding these ratings can cause damage, thermal runaway, or failure.

- Circuit Stability and Safety: Doubling voltage without appropriate design considerations may lead to safety hazards, including shorts, insulation breakdown, or fire.

Non-Linearities and Real-World Factors

While the idealized calculations assume constant resistance, real-world resistors may exhibit temperature-dependent resistance changes. As current and power increase, resistors tend to heat up, potentially altering resistance and affecting circuit behavior.

Additionally, other circuit elements (capacitors, inductors, semiconductors) could influence the response to voltage changes, rendering simple Ohm's Law insufficient for comprehensive analysis.

Broader Context and Applications

Voltage Scaling in Electronic Devices

Understanding how current responds to voltage changes is critical in designing electronic circuits, powering devices, and ensuring component longevity. For example:

- Power Supplies: Engineers must ensure that components can handle voltage fluctuations without failure.
- Signal Processing: Voltage adjustments are often used to control signal levels, necessitating precise current calculations.
- Energy Efficiency: Minimizing unnecessary power dissipation involves careful control of voltage and current.

Impacts on Power Systems and Safety Protocols

In larger power systems, voltage regulation and current management are vital for safety, efficiency, and reliability. The fundamental principles explored here underpin complex systems such as electrical grids, where voltage doubling or regulation must be managed meticulously.

Conclusion

This comprehensive analysis highlights the straightforward yet profound relationship between voltage and current in resistive circuits. Starting from a given voltage of 61.5 V across a 103.4 k Ω resistor, we established that the initial current is approximately 0.595 mA. When the supply voltage is doubled to 123 V, the current correspondingly doubles to approximately 1.19 mA, illustrating the linearity predicted by Ohm's Law.

However, practical considerations—such as thermal effects, component ratings, and real-world non-linearities—must be factored into any application involving voltage scaling. These insights are essential not only for fundamental circuit analysis but also for the design, safety, and efficiency of electrical and electronic systems. Understanding these principles enables engineers and technicians to predict circuit behavior accurately, optimize performance, and prevent failures in a wide array of technological domains.

References

- Hayt, W. H., & Buck, J. E. (2012). Engineering Circuit Analysis. McGraw-Hill Education.
- Sedra, A. S., & Smith, K. C. (2014). Microelectronic Circuits. Oxford University Press.
- IEEE Standards for Electrical Power Systems and Component Ratings.

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