

Five Resistors, Each 10 , Are Connected In Parallel To A Voltage Source.What Is The Equivalent Resistance

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Understanding how resistors work in electrical circuits is fundamental to both theoretical physics and practical electronics. When resistors are connected in various configurations, they influence the overall resistance and, consequently, the current flow through the circuit. In this article, we will delve into the concept of parallel resistor connections, specifically focusing on a scenario involving five resistors, each with a resistance of 10 ohms, connected in parallel to a voltage source. Our goal is to determine the equivalent resistance of this configuration, exploring the underlying principles, mathematical calculations, and real-world applications.

Introduction to Resistor Configurations

Resistors are passive electrical components that oppose the flow of current. They are characterized by their resistance value, measured in ohms (Ω). In circuit design, resistors can be connected in series or parallel configurations, each affecting the circuit's total resistance differently.

Series vs. Parallel Resistors

- Series Connection: Resistors are connected end-to-end, with the same current passing through each resistor. The total or equivalent resistance (R_{total}) is simply the sum of individual resistances:

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

- Parallel Connection: Resistors are connected across the same two points, providing multiple paths for current. The total resistance is less than the smallest individual resistor and is calculated using the reciprocal sum:

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

For our specific case, with five resistors each of 10 ohms connected in parallel, the parallel formula is most relevant.

Calculating the Equivalent Resistance of Parallel Resistors

The key to solving the problem lies in understanding the reciprocal sum formula for parallel resistances. Let's break down the steps:

Step 1: Recognize the Resistor Values

- Number of resistors, $(n = 5)$
- Resistance of each resistor, $(R = 10\, \Omega)$

Since all resistors have the same resistance, the calculation simplifies significantly.

Step 2: Apply the Parallel Resistance Formula

$$\frac{1}{R_{eq}} = \sum_{i=1}^n \frac{1}{R_i}$$

Given all resistors are identical:

$$\frac{1}{R_{eq}} = n \times \frac{1}{R}$$

Substituting the known values:

$$\frac{1}{R_{eq}} = 5 \times \frac{1}{10\, \Omega} = \frac{5}{10} = \frac{1}{2}$$

Step 3: Calculate the Equivalent Resistance

Invert the reciprocal sum:

$$R_{eq} = \frac{1}{\frac{1}{2}} = 2\, \Omega$$

Therefore, the equivalent resistance of five 10-ohm resistors connected in parallel is 2 ohms.

Visualizing the Parallel Connection

To better understand, imagine five branches of equal resistance connected across the same voltage source. Current can divide equally among the branches, and the total current flowing through the circuit is the sum of currents through each resistor.

Key points to note:

- The equivalent resistance is less than any individual resistor in the network.
- Increasing the number of resistors in parallel decreases the equivalent resistance.
- The total current increases with more parallel paths, given the same voltage.

Real-World Applications of Parallel Resistors

Parallel resistor arrangements are widespread in electronic devices, power systems, and circuit design for various purposes:

- Current Division: Distributing current evenly across components.
- Redundancy: Ensuring circuit operation even if one resistor fails.
- Voltage Regulation: Maintaining consistent voltage across components.
- Reducing Resistance: Achieving lower resistance values than individual components.

Examples include:

- Power distribution networks where multiple parallel paths reduce overall resistance.
- LED lighting circuits with parallel resistors for uniform brightness.
- Audio systems for balancing signals.

Additional Considerations and Practical Insights

While the calculation above assumes ideal resistors with precise resistance values, real-world resistors can have tolerances that slightly affect the total resistance. Typical tolerance levels (e.g., $\pm 5\%$) should be considered in precise applications.

Thermal effects: Resistors dissipate power as heat, especially when currents are high. Parallel arrangements can help distribute heat more evenly.

Component quality: Using high-quality resistors ensures stability of resistance values over temperature and time.

Extending the Concept: Series-Parallel Combinations

Most practical circuits involve complex combinations of series and parallel resistors. Calculating

equivalent resistance in such cases involves:

- Simplifying the circuit step-by-step by combining series and parallel groups.
- Redrawing the circuit after each simplification.
- Applying the appropriate formulas iteratively.

Example:

Suppose some of the resistors are in series while others are in parallel. The process involves:

1. Identifying simple series or parallel groups.
2. Calculating their equivalent resistances.
3. Replacing these groups with their equivalents and simplifying further.
4. Repeating until the circuit reduces to a single equivalent resistor.

Summary and Final Thoughts

The problem of determining the equivalent resistance of five 10-ohm resistors connected in parallel to a voltage source is straightforward when applying the parallel resistance formula. The key steps include recognizing the uniform resistor values, applying the reciprocal sum, and inverting the result to find the equivalent resistance.

Final answer:

$$\boxed{R_{eq} = 2\,\Omega}$$

This value indicates that connecting five 10-ohm resistors in parallel effectively reduces the total resistance to just 2 ohms, facilitating higher currents and lower overall resistance in the circuit.

Understanding these principles is essential for designing efficient electronic circuits, optimizing power distribution, and troubleshooting complex systems. Whether working on simple hobby projects or advanced engineering applications, mastering resistor networks enhances your ability to create reliable and effective electronic solutions.

Frequently Asked Questions

What is the equivalent resistance when five 10Ω resistors are connected in parallel?

The equivalent resistance is 2Ω.

How do you calculate the equivalent resistance for multiple resistors in parallel?

You use the formula $1/R_{eq} = 1/R_1 + 1/R_2 + \dots + 1/R_n$. For identical resistors, $R_{eq} = R / n$.

What is the total resistance of five 10Ω resistors connected in parallel?

The total resistance is 2Ω.

Does connecting resistors in parallel increase or decrease the overall resistance?

Connecting resistors in parallel decreases the overall resistance.

If each resistor is 10Ω, what is the current flowing through the circuit when connected to a 12V source?

The total resistance is 2Ω, so the current is $I = V / R = 12V / 2\Omega = 6A$.

Why does the equivalent resistance decrease when adding more resistors in parallel?

Because parallel resistances provide multiple pathways for current, reducing the total resistance.

Can the equivalent resistance of five 10Ω resistors in parallel be less than 1Ω?

No, in this case, it is 2Ω, which is greater than 1Ω.

What is the significance of calculating equivalent resistance in a parallel circuit?

It helps determine total current, voltage distribution, and power consumption in the circuit.

Additional Resources

Five Resistors, Each 10Ω, Are Connected In Parallel To A Voltage Source. What Is The Equivalent Resistance?

Introduction

In the realm of electrical engineering and circuit analysis, understanding how resistors combine in

various configurations is fundamental. Among the common arrangements, parallel connections are particularly significant due to their practical applications in distributing current and reducing overall resistance. The question of determining the equivalent resistance when multiple resistors are connected in parallel is a classic problem that exemplifies the importance of fundamental principles and mathematical rigor.

This article aims to thoroughly investigate the scenario where five resistors, each of 10Ω , are connected in parallel to a voltage source. We will delve into the principles governing parallel resistances, explore the step-by-step calculations, analyze the implications of the resulting equivalent resistance, and discuss practical considerations relevant to real-world applications.

Understanding Parallel Resistors: The Fundamentals

What Does a Parallel Connection Mean?

In a parallel circuit, multiple resistors are connected such that each resistor's terminals are directly connected across the same two nodes, sharing the same voltage across their terminals. This configuration ensures that:

- The voltage across each resistor is identical.
- The total current supplied by the source divides among the resistors.
- The total or equivalent resistance is less than any individual resistor in the network.

Mathematical Foundation

For resistors connected in parallel, the reciprocal of the equivalent resistance (R_{eq}) is equal to the sum of the reciprocals of the individual resistances ($R_1, R_2, \dots, R_n$):

$$\frac{1}{R_{eq}} = \sum_{i=1}^n \frac{1}{R_i}$$

In the case of identical resistors, this simplifies to:

$$\frac{1}{R_{eq}} = n \times \frac{1}{R}$$

where (n) is the number of resistors, and (R) is the resistance of each resistor.

Calculation of Equivalent Resistance for Five 10Ω Resistors in Parallel

Step-by-Step Calculation

Given:

- Number of resistors, $(n = 5)$
- Resistance of each resistor, $(R = 10\Omega)$

Applying the formula:

$$\frac{1}{R_{eq}} = n \times \frac{1}{R} = 5 \times \frac{1}{10\Omega}, \Omega = \frac{5}{10}, \Omega = \frac{1}{2\Omega}, \Omega$$

Inverting both sides to find (R_{eq}) :

$$R_{eq} = \frac{1}{\frac{1}{2\Omega}} = 2\Omega$$

Result

The equivalent resistance of five 10Ω resistors connected in parallel is 2Ω .

Deep Dive: Implications and Practical Significance

Voltage and Current Distribution

Since all five resistors are in parallel, each resistor experiences the same voltage (V) across its terminals. The total current supplied by the source (I_{total}) is the sum of the currents through each resistor:

$$I_{total} = \sum_{i=1}^5 I_i = 5 \times I_{single}$$

By Ohm's Law:

$$I_{single} = \frac{V}{R} = \frac{V}{10\Omega}$$

Thus,

$$I_{total} = 5 \times \frac{V}{10\Omega} = \frac{V}{2\Omega}$$

which aligns with the total current flowing through the equivalent resistor $(R_{eq} = 2\Omega)$:

$$I_{total} = \frac{V}{R_{eq}} = \frac{V}{2\Omega}$$

This consistency underscores the utility of equivalent resistance in simplifying complex circuits.

Power Dissipation Considerations

Power dissipated by each resistor:

$$P_i = I_i^2 \times R = \left(\frac{V}{R} \right)^2 \times R = \frac{V^2}{R}$$

Total power dissipated:

$$P_{\text{total}} = 5 \times \frac{V^2}{10\,\Omega} = \frac{V^2}{2\,\Omega}$$

The power distribution indicates that each resistor dissipates the same power, which is crucial for thermal management and component ratings.

Practical Applications and Design Considerations

Circuit Design and Load Management

Understanding the equivalent resistance helps engineers design circuits that meet specific current and voltage requirements. For instance, in power distribution, parallel resistors reduce the overall resistance, allowing higher current flow without exceeding individual resistor ratings.

Reliability and Redundancy

Parallel resistor configurations provide redundancy; if one resistor fails (opens), the overall resistance increases but the circuit remains operational. This feature is exploited in critical systems requiring high reliability.

Limitations and Real-World Deviations

While ideal resistors are assumed to have fixed resistance, real resistors exhibit tolerance, temperature dependence, and parasitic inductance or capacitance. These factors can slightly alter the actual resistance, especially under high power or varying environmental conditions.

Advanced Topics: Variations and Extensions

Mixed Series-Parallel Networks

In complex circuits, resistors are often arranged in combinations of series and parallel, requiring systematic analysis or the use of network reduction techniques.

Non-Identical Resistors

When resistors have different values, the same formula applies, but the summation involves

individual reciprocals:

$$\frac{1}{R_{eq}} = \sum_{i=1}^n \frac{1}{R_i}$$

This often necessitates more detailed calculations and sometimes the use of computational tools.

Summary and Conclusions

To revisit the initial question: Five resistors, each 10Ω , connected in parallel to a voltage source, have an equivalent resistance of 2Ω . This result stems from fundamental principles of parallel resistor networks and straightforward mathematical derivation.

Key points:

- The reciprocal of the equivalent resistance for parallel resistors is the sum of the reciprocals of individual resistances.
- For identical resistors, the equivalent resistance is simply (R/n) .
- The equivalent resistance significantly impacts current distribution, power dissipation, and overall circuit behavior.
- Practical applications benefit from understanding these principles to ensure safe, efficient, and reliable circuit design.

This analysis exemplifies the importance of foundational circuit theory in both educational contexts and practical engineering applications. Whether designing simple circuits or complex power systems, mastering the calculation and implications of equivalent resistance remains an essential skill.

References

1. Nilsson, J. W., & Riedel, S. (2015). Electric Circuits. Pearson.
2. Dorf, R. C., Svoboda, J. A. (2014). Introduction to Electric Circuits. Wiley.
3. Hayt, W. H., Kemmerly, J. E., & Durbin, S. M. (2018). Engineering Circuit Analysis. McGraw-Hill Education.

This detailed exploration underscores the significance of basic circuit principles and their applications, providing a comprehensive understanding suitable for students, educators, and practicing engineers alike.

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[Source What Is The Equivalent Resistance](#)

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