

Three Loads, Of 24 A, 8 A, And 12 A Are Supplied From A 200 V Source. If A Motor Of Resistance 2.4 Ohms

Three Loads, Of 24 A, 8 A, And 12 A Are Supplied From A 200 V Source. If A Motor Of Resistance 2.4 Ohms presents an intriguing electrical scenario that involves analyzing the power distribution, current flow, and the behavior of a motor connected to a common power source. Understanding these concepts is essential for electrical engineers, students, and technicians working with circuit design, load management, and motor operation. This article explores the fundamental principles involved in such a setup, providing a detailed analysis of the loads, the motor, and their interactions with a 200 V supply.

Understanding the Basic Electrical Setup

Overview of the Loads

In this scenario, three distinct loads are supplied from a single 200 V source:

- A load drawing 24 A
- A load drawing 8 A
- A load drawing 12 A

These loads could represent resistive devices such as heaters, lamps, or other electrical appliances. The total current supplied by the source depends on how these loads are connected—whether in series or parallel.

Connection Types and Their Impact

The configuration of the loads significantly affects the overall system behavior:

- **Parallel Connection:** Each load receives the full voltage (200 V) and draws its specified current independently. The total current supplied by the source is the sum of individual currents.
- **Series Connection:** The current is the same through all loads, but the voltage divides among them depending on their resistances.

Given the load currents provided, it is most probable these loads are connected in parallel, which is common in such high-current applications.

Calculating Power Consumption of Each Load

Resistive Loads and Power Calculation

If the loads are resistive, we can determine their resistances using Ohm's Law:

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

where $(V = 200\text{V})$.

- Resistance of each load:

- For 24 A load: $(R_{24A} = \frac{200V}{24A} \approx 8.33\Omega)$
- For 8 A load: $(R_{8A} = \frac{200V}{8A} = 25\Omega)$
- For 12 A load: $(R_{12A} = \frac{200V}{12A} \approx 16.67\Omega)$

- Power consumed by each load:

$$P = V \times I$$

or equivalently,

$$P = I^2 R$$

- Calculations:

- 24 A load: $(P_{24A} = 200V \times 24A = 4800\text{W})$
- 8 A load: $(P_{8A} = 200V \times 8A = 1600\text{W})$
- 12 A load: $(P_{12A} = 200V \times 12A = 2400\text{W})$

- Total power consumption:

$$P_{\text{total}} = 4800\text{W} + 1600\text{W} + 2400\text{W} = 8800\text{W}$$

This indicates the total load draws 8.8 kW from the 200 V source, with the current drawn summing to 44 A if connected in parallel (since $(24A + 8A + 12A = 44A)$).

Analyzing the Motor with Resistance of 2.4 Ohms

Motor Resistance and Operating Principles

A motor modeled as a resistor of 2.4 Ohms is a simplified way to understand its electrical characteristics. In practical applications, motors are more complex, involving inductance, back emf, and torque, but resistance provides a starting point.

- Current through the motor:

$$I_{\text{motor}} = \frac{V}{R_{\text{motor}}} = \frac{200\text{V}}{2.4\,\Omega} \approx 83.33\text{A}$$

- Power dissipated in the motor:

$$P_{\text{motor}} = V \times I_{\text{motor}} = 200\text{V} \times 83.33\text{A} \approx 16,666\text{W}$$

Alternatively,

$$P_{\text{motor}} = I_{\text{motor}}^2 \times R_{\text{motor}} = (83.33)^2 \times 2.4 \approx 16,666\text{W}$$

This high power indicates significant heat generation and the need for proper cooling and circuit protection.

Implications of Connecting the Motor to the Same Source

Connecting this motor directly to the same 200 V source as the loads can have several implications:

- **Total Current Draw:** The motor alone draws over 83 A, which is significantly higher than the combined load current of 44 A, potentially causing overloads if not properly managed.
- **Voltage Stability:** The high current draw by the motor might cause voltage drops, affecting other loads and possibly leading to system instability.
- **Protection Devices:** Proper circuit protection, such as circuit breakers and fuses rated for the maximum current, is essential to prevent damage.

Power System Design Considerations

Ensuring Safe and Efficient Operation

Designing a system with such loads requires careful planning:

- Calculate the total current demand and ensure the supply can handle peak loads.
- Implement appropriate protective devices to prevent overloads and short circuits.

- Use proper wiring and conductors rated for the maximum current.
- Consider the power factor, especially with inductive loads like motors, which can introduce reactive power issues.

Power Factor Correction

Motors and inductive loads tend to have low power factors. Power factor correction devices, such as capacitors, can improve efficiency and reduce energy costs:

- Assess the overall power factor of the system.
- Install capacitor banks to offset inductive effects.

Summary and Practical Applications

This analysis provides insights into the behavior of multiple loads supplied from a single source, emphasizing the importance of proper load calculation, system protection, and motor considerations.

- Key Takeaways:

- The total current drawn by the loads is the sum of individual currents, assuming parallel connection.
- Resistive calculations help determine power consumption and resistance values.
- A motor modeled as a resistor of 2.4 Ohms draws a significant current, necessitating careful system design.
- Proper protection and power factor correction are vital for safe and efficient operation.

- Applications:

- Industrial motor control systems
- Load management in electrical distribution systems
- Designing circuits for multiple resistive loads and motor drives
- Ensuring system safety and compliance with electrical standards

Final Thoughts

Understanding the interplay between multiple loads, their resistances, and motor behavior is crucial for designing reliable electrical systems. Whether in industrial settings or residential applications, accurate calculations and thoughtful system design ensure safety, efficiency, and longevity of electrical components. By assessing current, power, and potential issues such as voltage drops and overloads, engineers can optimize system performance and prevent costly failures.

Keywords: electrical loads, current calculation, power consumption, motor resistance, 200 V supply, load analysis, circuit design, power factor correction, electrical safety, resistive loads

Frequently Asked Questions

What is the total current supplied from the 200 V source when three loads of 24 A, 8 A, and 12 A are connected?

The total current is the sum of the individual loads: $24\text{ A} + 8\text{ A} + 12\text{ A} = 44\text{ A}$.

How do you calculate the power consumed by each load in this circuit?

Power for each load is calculated using $P = V \times I$, assuming they are connected across the 200 V source: for the 24 A load, $P = 200\text{ V} \times 24\text{ A} = 4800\text{ W}$; similarly for others, if voltage is the same.

What is the current flowing through the motor with a resistance of 2.4 ohms when connected to a 200 V source?

Using Ohm's law, current $I = V / R = 200\text{ V} / 2.4\text{ }\Omega \approx 83.33\text{ A}$.

What is the power dissipated in the motor resistor of 2.4 ohms when connected to the 200 V source?

Power $P = V^2 / R = (200\text{ V})^2 / 2.4\text{ }\Omega \approx 16,666.67\text{ W}$.

Are the loads connected in series or parallel, and how does that affect the total current?

Typically, loads like these are connected in parallel across the voltage source, so each load draws its own current independently, resulting in a total current equal to the sum of individual currents.

What are the implications of a motor having a resistance of 2.4 ohms in terms of power consumption and heat dissipation?

With a resistance of 2.4 ohms at 200 V, the motor consumes approximately 16.67 kW of power, leading to significant heat dissipation, which requires adequate cooling measures to prevent damage.

Additional Resources

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Introduction

Understanding electrical load distribution and the behavior of circuits involving multiple loads and a motor component is fundamental in electrical engineering and power system analysis. When multiple loads draw current from a common source, the resulting voltage drops, power dissipation, and efficiency are deeply interconnected. This article explores a scenario where three distinct loads—drawing currents of 24 A, 8 A, and 12 A—are supplied from a 200 V source, alongside a motor with a resistance of 2.4 ohms. We will analyze the circuit's behavior, voltage drops, power consumption, and the impact of the motor's resistance, providing a comprehensive understanding of the system's electrical characteristics.

Section 1: Basic Circuit Configuration and Assumptions

1.1 Description of the System

The system under consideration involves a single power source and multiple loads connected in a particular configuration. The key elements are:

- Power Source: A 200 V DC supply (assuming direct current for simplicity).
- Loads: Three resistive loads with currents of:
 - Load 1: 24 A
 - Load 2: 8 A
 - Load 3: 12 A
- Motor: Characterized by a resistance of 2.4 ohms.

The primary assumptions for analysis include:

- All loads are connected in parallel to the source, which is a common configuration in power distribution systems.
- The motor is modeled as a resistor (i.e., neglecting inductance, back emf, or other motor characteristics for initial analysis).
- The source maintains a constant voltage of 200 V under load conditions.
- No additional elements like transformers, switches, or complex motor dynamics are considered unless specified.

1.2 Basic Electrical Principles Applied

In analyzing this system, the fundamental principles include:

- Ohm's Law: $(V = IR)$
- Power Calculation: $(P = VI)$ or $(P = I^2 R)$
- Parallel Circuit Behavior: The voltage across each parallel branch remains constant at the source voltage, while the currents add up to the total supplied current.

Section 2: Analyzing the Loads and Their Power Consumption

2.1 Calculating Power Dissipation of Each Load

Given the currents drawn and the supply voltage:

- Load 1 (24 A):

$$R_1 = \frac{V}{I_1} = \frac{200\text{V}}{24\text{A}} \approx 8.33\,\Omega$$

Power:

$$P_1 = V \times I_1 = 200\text{V} \times 24\text{A} = 4800\text{W}$$

or equivalently:

$$P_1 = I_1^2 R_1 = (24)^2 \times 8.33 \approx 576 \times 8.33 \approx 4800\text{W}$$

- Load 2 (8 A):

$$R_2 = \frac{200\text{V}}{8\text{A}} = 25\,\Omega$$

Power:

$$P_2 = 200\text{V} \times 8\text{A} = 1600\text{W}$$

or:

$$P_2 = (8)^2 \times 25 = 64 \times 25 = 1600\text{W}$$

- Load 3 (12 A):

$$R_3 = \frac{200\text{V}}{12\text{A}} \approx 16.67\,\Omega$$

Power:

$$\backslash$$

$$P_3 = 200\text{ V} \times 12\text{ A} = 2400\text{ W}$$

\]

or:

\[

$$P_3 = (12)^2 \times 16.67 \approx 144 \times 16.67 \approx 2400\text{ W}$$

\]

Total Power Consumed by Loads:

\[

$$P_{\text{total, loads}} = P_1 + P_2 + P_3 = 4800 + 1600 + 2400 = 8800\text{ W}$$

\]

Total Current Drawn from the Source:

\[

$$I_{\text{total}} = 24\text{ A} + 8\text{ A} + 12\text{ A} = 44\text{ A}$$

\]

Section 3: Impact of the Motor Resistance and Circuit Behavior

3.1 Motor as a Resistive Load

The motor is modeled as a resistor with resistance $(R_m = 2.4\text{ }\Omega)$. Assuming it is connected in parallel with the other loads, the motor's current at 200 V:

\[

$$I_m = \frac{V}{R_m} = \frac{200\text{ V}}{2.4\text{ }\Omega} \approx 83.33\text{ A}$$

\]

This is a significant current, and its inclusion dramatically alters the total current drawn from the source. The total load current becomes:

\[

$$I_{\text{total, with motor}} = 44\text{ A} + 83.33\text{ A} \approx 127.33\text{ A}$$

\]

Power consumed by the motor:

\[

$$P_m = V \times I_m = 200\text{ V} \times 83.33\text{ A} \approx 16,666\text{ W}$$

\]

or, equivalently,

$$P_m = I_m^2 \times R_m = (83.33)^2 \times 2.4 \approx 6944.44 \times 2.4 \approx 16,666 \text{ W}$$

Implication:

The motor, modeled purely resistively, dominates the total current and power consumption, illustrating the importance of motor characteristics in real-world applications. In practice, motors are not purely resistive and have back emf and inductance that limit current, but this simplified model underscores the impact of resistance.

3.2 Voltage Drop Analysis in the Circuit

In any real system, the source and wiring have internal resistances and impedance, causing voltage drops proportional to current. For an ideal scenario with no wiring resistance:

- The voltage across each load and the motor would be 200 V.
- The total current is the sum of individual currents.

However, if wiring resistance or other series resistances are considered, the actual voltage at each load may decrease, affecting power delivery.

Suppose the wiring has a total resistance (R_{wire}) . The voltage at the loads becomes:

$$V_{\text{load}} = V_{\text{source}} - I_{\text{total}} \times R_{\text{wire}}$$

This reduces the voltage across each load and motor, consequently decreasing the currents and power dissipation.

Realistic scenario considerations:

- Larger currents, especially from the motor, increase the voltage drop.
- Proper cable sizing and impedance management are vital for system stability and efficiency.

Section 4: System Efficiency and Power Management

4.1 Calculating Total Power Supplied and Lost

Total power supplied by the source:

$\backslash$

$$P_{\text{supply}} = V \times I_{\text{total,with,motor}} = 200\text{V} \times 127.33\text{A} \approx 25,466\text{W}$$

Total power dissipated in loads and motor:

$$P_{\text{loads}} + P_{\text{m}} \approx 8800\text{W} + 16,666\text{W} = 25,466\text{W}$$

This confirms the power supplied equals the power consumed, neglecting losses in wiring and connections.

Power losses in wiring:

If wiring resistance (R_{wire}) is present, it results in additional losses:

$$P_{\text{loss}} = (I_{\text{total}})^2 \times R_{\text{wire}}$$

Minimizing (R_{wire}) is critical for efficiency, especially with high currents.

4.2 Efficiency Considerations

Efficiency (η) of the system can be assessed as:

$$\eta = \frac{\text{Total Power Useful (Loads + Motor)}}{\text{Total Power Supplied}}$$

In an ideal, lossless system, efficiency would be 100%. In real systems:

- Resistance in conductors causes heat losses.
- Motor inefficiencies due to friction, windage, and electrical losses reduce the effective power output.
- Proper system design aims to maximize efficiency by reducing resistive losses, optimizing motor performance, and ensuring proper load management.

Section 5: Practical Implications and Engineering Considerations

5.1 Load Balancing and System Design

In power distribution, balancing loads is crucial to prevent overloading and ensure stability. The scenario described highlights:

- The importance of understanding individual load characteristics.
- The impact of high-current loads like motors on system capacity.
- The need for appropriate wiring and protective devices.

5.2 Motor Control and Protective Measures

Using a purely resistive model for a motor simplifies analysis but is not reflective of real motor behavior. Actual motors:

- Have

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