JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 3, July 2026
Page: 208-217
ISSN 3089-106X
(online)

Modeling and Performance Analysis of a Series-Parallel AC Circuit under Supply Voltage Variations Using Simulation

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Submitted : 3 July 2026 | **Accepted** : 20 July 2026 | **Published** : 21 July 2026

Abstract: Series-parallel Alternating Current (AC) circuits are widely used in electrical power distribution and electronic systems because their operating characteristics are strongly influenced by supply voltage variations. Although simulation-based circuit analysis using Multisim has been widely applied in engineering education, studies systematically investigating the operating characteristics of series-parallel AC circuits over a broad range of supply voltages remain limited. This study aims to analyze the effect of gradual supply voltage variation on the operating characteristics of a series-parallel AC circuit using Multisim simulation. A quantitative experimental approach based on computer simulation was employed. The simulated circuit consisted of two resistors (220 Ω and 230 Ω) and two lamps connected as electrical loads. The supply voltage was gradually varied from 100 V to 320 V to observe changes in the operating conditions of the loads. The simulation showed that increasing the supply voltage progressively changed the lamp operating conditions, ranging from no illumination at 100 V, low brightness at 130 V, gradual increases in brightness at intermediate voltage levels, maximum brightness at 300 V, and lamp failure at 320 V due to excessive applied voltage. These observations are consistent with the theoretical relationships described by Ohm's Law, where increasing supply voltage results in greater electrical power delivered to resistive loads. The findings suggest that Multisim provides a practical environment for the preliminary evaluation of circuit behavior under different supply voltage conditions. However, the conclusions of this study are limited to simulation-based observations and require further validation through quantitative electrical measurements and hardware experiments.

Keywords: Series-Parallel AC Circuit, Voltage Variation, Multisim, Circuit Simulation, Electronics.

INTRODUCTION

Advances in electrical and electronic technology have significantly increased the demand for reliable methods to analyze electrical circuit performance under various operating conditions. Among the fundamental circuit configurations, series-parallel Alternating Current (AC) circuits are widely applied in residential electrical installations, industrial power distribution systems, and electronic devices because they combine the advantages of both series and parallel connections in current distribution, voltage regulation, and operational flexibility. Understanding the operating characteristics of these circuits is essential for ensuring system reliability, optimizing electrical performance, and supporting engineering design as well as educational activities(Saputri et al., 2025).

The performance of a series-parallel AC circuit is strongly influenced by variations in the supply voltage. According to Ohm's Law and the fundamental principles of AC circuit analysis, changes in the applied voltage directly affect the electric current, electrical power, and operating conditions of the connected loads. Under-voltage conditions may reduce circuit performance, whereas excessive voltage may accelerate component degradation or even cause equipment failure. Therefore, investigating the effect of supply voltage variation on electrical circuit behavior is important not only for understanding theoretical electrical principles but also for supporting safer circuit operation and improving system reliability in practical applications (Mabruroh et al., 2025).

JCEIT: Journal of Computer Engineering and Information Technology
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Experimental investigation of electrical circuit behavior under different voltage conditions often encounters several practical limitations. Physical laboratory experiments require electrical components, measuring instruments, and controlled testing environments while also involving safety risks when circuits are operated under over-voltage conditions. In addition, repeated experiments across multiple voltage levels increase both experimental cost and component replacement requirements. Consequently, computer-based circuit simulation has become an effective alternative for analyzing electrical circuit behavior because it provides a safe, flexible, and cost-efficient environment for evaluating circuit performance before hardware implementation (Nasab et al., 2024).

Simulation software such as Multisim has been extensively employed in electrical engineering education and circuit analysis due to its capability to accurately model electrical components and predict circuit behavior under various operating conditions (Saha, 2022). Previous studies have demonstrated that Multisim effectively supports circuit visualization, verification of electrical principles, and laboratory learning while reducing experimental risks and equipment costs (Halim et al., 2024; Zhang & Pan, 2023). Similarly, studies investigating voltage-current relationships through simulation have confirmed that simulation results closely follow the theoretical relationships described by Ohm's Law (Hilma & Malik, 2024). These findings indicate that simulation-based approaches are reliable tools for analyzing electrical circuits under controlled conditions.

Despite these contributions, previous studies have primarily focused on validating theoretical concepts, improving learning outcomes, or analyzing electrical circuits under normal operating conditions. Relatively few studies have systematically investigated the operating characteristics of series-parallel AC circuits across a continuous range of supply voltages extending from under-voltage to over-voltage conditions. Furthermore, most existing studies emphasize the educational application of simulation software rather than examining the engineering characteristics of circuit performance, including the operational transition from insufficient operating voltage to component failure (Ridwan & Kembuan, 2021).

The novelty of this study lies in the systematic investigation of gradual supply voltage variation ranging from 100 V to 320 V in a series-parallel AC circuit using Multisim simulation. Unlike previous studies that mainly focused on theoretical verification or educational implementation, this research evaluates the complete operating transition of electrical loads from under-voltage conditions, normal operation, over-voltage conditions, and eventual load failure within a controlled simulation environment. This approach provides additional insight into the voltage tolerance characteristics of electrical loads and demonstrates the capability of simulation for evaluating circuit performance under operating conditions that are difficult and potentially unsafe to reproduce experimentally (Dewy & Isnaini, 2022).

Based on the identified research gap, this study aims to analyze the effect of supply voltage variation on the operating characteristics of a series-parallel AC circuit using Multisim simulation. The investigation focuses on observing the changes in lamp operating conditions as indicators of circuit performance over a supply voltage range of 100 V to 320 V. Beyond its contribution to simulation-based electrical engineering education, this study also provides engineering insights into the influence of supply voltage on circuit behavior, component operating limits, and preliminary circuit evaluation prior to hardware implementation.

LITERATURE REVIEW

Series-Parallel Alternating Current (AC) Circuit

Series-parallel AC circuits are among the most fundamental circuit configurations in electrical engineering because they combine the characteristics of both series and parallel connections within a single electrical network (Sidiq & Sukandar, 2023). This configuration is widely implemented in residential electrical installations, industrial power distribution systems, and electronic equipment due to its ability to provide flexible current distribution, stable voltage allocation, and improved operational reliability (Saputri et al., 2025). The electrical behavior of a series-parallel AC circuit is governed by the interaction between voltage, current, impedance, and the arrangement of circuit components. Consequently, changes in one electrical parameter, particularly the supply voltage, may influence the operating characteristics of the entire circuit as well as the performance of the connected electrical loads.

Previous studies have extensively investigated the analysis of series-parallel AC circuits from both theoretical and simulation perspectives. Surahmat & Dedy Fu'ady, (2020) demonstrated that simulation-based circuit analysis effectively supports the understanding of current distribution and voltage characteristics in series and parallel electrical networks. Similarly, Halim et al., (2024) reported that computer-based simulation provides an efficient and safe approach for analyzing electrical circuit behavior while reducing the need for repeated hardware experiments. Other researchers have also highlighted that simulation platforms facilitate visualization of electrical phenomena that are often difficult to observe directly during conventional laboratory activities, thereby improving both engineering analysis and learning effectiveness (Rangkuti, 2026).

Despite these contributions, most previous studies have primarily focused on verifying fundamental electrical concepts or evaluating the effectiveness of simulation as a learning tool. Comparatively fewer studies have systematically examined the operating characteristics of series-parallel AC circuits under gradual variations of supply voltage extending from under-voltage to over-voltage conditions (Anindya et al, 2025). Moreover, existing studies generally emphasize theoretical verification or educational outcomes rather than analyzing the operational response of electrical loads across a wide voltage range, including conditions that may lead to component failure.

Therefore, this study extends previous research by systematically investigating the influence of supply voltage variation on the operating characteristics of a series-parallel AC circuit using Multisim simulation. By gradually varying the supply voltage from 100 V to 320 V, the present study provides a comprehensive evaluation of circuit behavior under both normal and abnormal operating conditions. The findings are expected to contribute not only to simulation-based electrical engineering education but also to a better understanding of circuit performance and the operating limits of electrical loads before practical hardware implementation.

Ohm's Law

Ohm's Law is a fundamental principle in electrical circuit analysis that describes the relationship among voltage, current, and resistance Mathematically, this relationship is expressed as

$$V = I \times R \tag{1}$$

where V denotes the applied voltage (V), I represents the electric current (A), and R is the electrical resistance (Ω). According to this equation, when the resistance remains constant, an increase in the applied voltage results in a proportional increase in the electric current flowing through the circuit. Consequently, changes in current directly affect the electrical power delivered to the load, which in turn influences the operating performance of electrical devices (Putri et al, 2025).

Previous studies have consistently confirmed the validity of Ohm's Law through both experimental measurements and computer-based simulations. Putri et al, (2025) reported that increasing the supply voltage proportionally increased the electric current in series and parallel circuits, demonstrating strong agreement with the theoretical prediction of Ohm's Law. Similarly, employed PhET simulation to investigate the relationship between voltage, resistance, and current, concluding that simulation-based analysis can accurately represent the electrical characteristics predicted by theory. In addition, Malik et al., (2020) emphasized that changes in current resulting from voltage variation directly influence the electrical power supplied to resistive loads, thereby affecting their operating conditions and overall performance.

Although these previous studies successfully validated the relationship among voltage, current, and resistance, most of them primarily focused on verifying the theoretical concepts of Ohm's Law or investigating electrical parameters under normal operating conditions. Limited attention has been given to analyzing the operating characteristics of series-parallel AC circuits over a wide range of supply voltages, particularly under gradual transitions from under-voltage to over-voltage conditions that may lead to load failure. Therefore, in the present study, Ohm's Law serves not only as the theoretical foundation for interpreting the simulation results but also as the analytical framework for explaining the changes in circuit behavior observed under systematic supply voltage variations using Multisim simulation software.

Multisim as an Electronic Circuit Simulation Platform

Multisim is a SPICE (Simulation Program with Integrated Circuit Emphasis)-based electronic circuit simulation software that has been widely adopted in electrical engineering education, research, and circuit design due to its capability to simulate electrical systems accurately without requiring physical hardware(Fan et al., 2026; Nuryanto, 2017). The software provides a comprehensive library of electrical and electronic components, including resistors, capacitors, inductors, AC and DC voltage sources, lamps, and various virtual measuring instruments such as voltmeters, ammeters, oscilloscopes, and digital multimeters. These features enable users to design, modify, and evaluate circuit performance in a flexible and controlled virtual environment while minimizing the risks associated with hardware experiments (Rupawanti, 2018).

Numerous studies have demonstrated the effectiveness of Multisim in supporting both engineering analysis and electronics education. Halim et al., (2024) reported that the integration of Multisim into laboratory activities significantly improved students' understanding of electrical circuit concepts by enabling direct visualization of voltage, current, and circuit behavior. Similarly, Zhang & Pan (2023)showed that simulation-based learning using Multisim enhanced students' analytical skills while providing a safer and more cost-effective alternative to conventional laboratory experiments. Fan et al., 2026) further highlighted that SPICE-based simulation platforms can accurately predict circuit performance and serve as reliable tools for preliminary validation before hardware implementation.

Despite these advantages, most previous studies have primarily employed Multisim as an instructional medium to improve learning outcomes or to verify basic electrical theories such as Ohm's Law and Kirchhoff's Law. Comparatively fewer studies have utilized Multisim as a systematic research tool for investigating the operating characteristics of series-parallel AC circuits under gradual supply voltage variations (Sya'ban et al., 2024). Furthermore, previous investigations generally focused on normal operating conditions and provided limited discussion of circuit behavior under under-voltage and over-voltage conditions that may lead to component degradation or failure.

Therefore, this study extends the existing literature by employing Multisim not only as an educational platform but also as an analytical tool to systematically evaluate the response of a series-parallel AC circuit across a wide range of supply voltages. Through gradual voltage variations from 100 V to 320 V, this research provides a more comprehensive understanding of circuit operating characteristics, load behavior, and component operating limits under both normal and abnormal electrical conditions.

Effect of Voltage Variation on Lamp Performance

The operating performance of electrical loads is strongly influenced by the supply voltage, as changes in voltage directly affect the current flowing through the circuit and the electrical power delivered to the load. For resistive loads such as incandescent lamps, electrical power is expressed by the relationship

$$P = V \times I \tag{2}$$

Where P represents electrical power (W), V is the applied voltage (V), and I is the electric current (A). Based on Ohm's Law, when the resistance remains relatively constant, an increase in the supply voltage results in a corresponding increase in electric current and electrical power, leading to higher light intensity. Conversely, a reduction in supply voltage decreases the electrical power delivered to the lamp, causing lower brightness or preventing the lamp from illuminating altogether (Malik et al., 2020).

Previous studies have consistently reported that supply voltage is one of the primary factors affecting the operating characteristics of electrical loads. Malik et al., (2020), demonstrated that variations in electrical power resulting from changes in voltage significantly influence lamp brightness and overall operating performance. Similarly, (Hilma & Malik, 2024)found that increasing the supply voltage in simulation-based experiments produced proportional increases in electric current, confirming the theoretical relationship among voltage, current, and electrical power. (Saputri et al., 2025)further reported that voltage variation directly affects current distribution in electrical circuits, thereby influencing the efficiency of power delivery to connected loads.

Although these studies successfully explain the relationship between voltage and electrical load performance, they generally focus on verifying theoretical electrical principles or measuring electrical parameters under normal operating conditions. Limited attention has been given to systematically investigating how gradual voltage variation influences the complete operating transition of electrical loads, beginning from under-voltage conditions, continuing through normal operation, and eventually reaching over-voltage conditions that may cause component failure. Such comprehensive analysis is important because electrical equipment frequently experiences voltage fluctuations in practical applications, making it necessary to understand both normal and abnormal operating characteristics.

Therefore, the present study investigates the effect of systematic supply voltage variation on the operating characteristics of lamps connected in a series-parallel AC circuit using Multisim simulation. By gradually increasing the supply voltage from 100 V to 320 V, this study provides a comprehensive analysis of changes in lamp operating conditions, ranging from no illumination and gradual brightness increase to maximum illumination and eventual lamp failure. The findings contribute to a better understanding of voltage tolerance, circuit performance, and the operational limits of electrical loads under different supply voltage conditions (Bhowmic, 2024).

Conceptual Framework

Based on the literature reviewed, supply voltage is considered the primary independent variable influencing the operating characteristics of a series-parallel AC circuit. According to Ohm's Law, variations in the applied voltage directly affect the electric current flowing through the circuit when the resistance remains constant. Consequently, changes in electric current alter the electrical power delivered to the connected loads, resulting in different operating conditions of the lamps. Under low-voltage conditions, the electrical power supplied to the lamps is insufficient to produce visible illumination. As the supply voltage increases, the electrical power also increases, leading to progressively brighter illumination. However, when the applied voltage exceeds the rated operating voltage of the load, excessive electrical power may cause overheating and eventual component failure.

Previous studies have established the theoretical relationships among voltage, current, resistance, and electrical power, as well as the effectiveness of Multisim in simulating electrical circuit behavior. Nevertheless, limited research has systematically investigated the complete operating transition of a series-parallel AC circuit under gradual supply voltage variations extending from under-voltage to over-voltage conditions. Therefore, this study employs Multisim simulation to evaluate the response of a series-parallel AC circuit over a voltage range of 100 V to 320 V. The simulation enables controlled observation of changes in lamp operating conditions as indicators of circuit performance while eliminating the safety risks associated with physical laboratory experiments.

The conceptual framework of this study assumes that systematic variation of the supply voltage influences the electrical behavior of the circuit, which is reflected in the operating condition of the electrical loads. The simulation results are interpreted based on the fundamental principles of Ohm's Law and electrical power relationships to explain the effect of voltage variation on the performance of the series-parallel AC circuit.

METHOD

This study employed a simulation-based experimental research method with a quantitative approach to analyze the effect of voltage variation on the characteristics of a series-parallel AC circuit. The simulation was conducted using Multisim software, which served as a virtual laboratory for designing, testing, and analyzing the behavior of electrical circuits without requiring direct hardware implementation. This approach was selected because it provides a safe, efficient, and flexible testing environment, enabling systematic modification of circuit parameters and observation of the resulting changes in circuit characteristics.

The circuit used in this study was a series-parallel AC configuration consisting of a single AC voltage source, two 220 V AC lamps as electrical loads, two resistors with resistance values of 220 Ω and 230 Ω, and virtual measuring instruments, including a voltmeter and an ammeter available in Multisim. All components were connected according to the predetermined circuit configuration to ensure that the electrical characteristics could be observed under each testing condition. Throughout the experiment, the resistor values were kept constant, while the supply voltage was treated as the independent variable and systematically varied to investigate its effect on the electric current characteristics and lamp operating conditions.

The research procedure began with the design of the series-parallel AC circuit in the Multisim simulation environment. After all components had been connected according to the planned configuration, the simulation was performed by gradually varying the supply voltage to 100 V, 130 V, 170 V, 200 V, 220 V, 240 V, 260 V, 280 V, 300 V, and 320 V AC. For each voltage level, the circuit response to changes in the electrical parameters was observed. The observations focused on the magnitude of the electric current flowing through the circuit and the operating condition of the lamps, as indicated by their brightness. All observation results were recorded and used as the research data for subsequent analysis.

The data obtained from each simulation scenario were analyzed using descriptive quantitative methods based on the principles of Ohm's Law and the characteristics of series-parallel circuits. The analysis involved comparing the changes in electric current and lamp operating conditions at each voltage level to identify the relationship between supply voltage variation and circuit performance. The findings were then interpreted based on established electrical engineering principles to evaluate the consistency between the simulation results and the fundamental concepts of electronics, as well as to explain the effect of increasing supply voltage on the operating characteristics of the series-parallel AC circuit.

RESULT

This study was conducted to investigate the effect of supply voltage variation on the operating characteristics of a series-parallel AC circuit using Multisim simulation. The supply voltage was gradually increased from 100 V to 320 V while maintaining constant resistor values of 220 Ω and 230 Ω. The simulation focused on observing changes in the operating condition of the lamp loads as qualitative indicators of circuit performance. Although quantitative electrical parameters such as current and power were not directly recorded in this study, the observed changes in lamp operating conditions were interpreted based on the fundamental relationships among voltage, current, and electrical power described by Ohm's Law.

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(online)

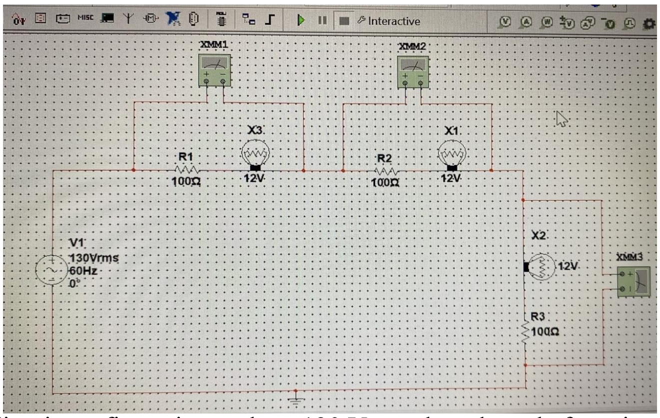

Fig. 1 Circuit configuration under a 130 V supply voltage before simulation.

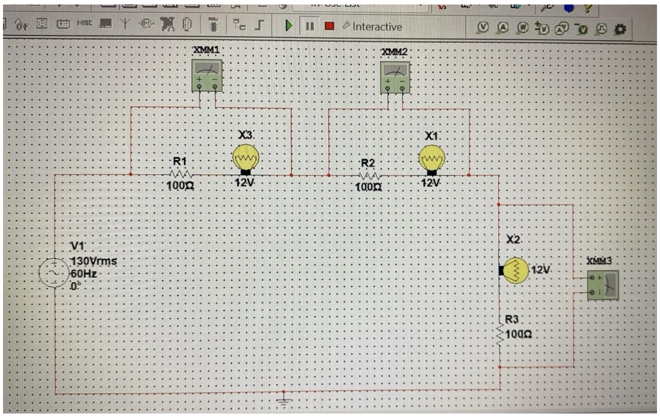

Fig. 2 Circuit configuration under a 130 V supply voltage after simulation.

Within the voltage range of 220 V to 300 V, the lamps operated with progressively increasing brightness. This observation indicates that an increase in the supply voltage has a direct effect on the ability of the electrical load to convert electrical energy into light. The maximum illumination was achieved at a supply voltage of 300 V, indicating that the circuit was still capable of operating optimally under these conditions (Figs.3 and 4).

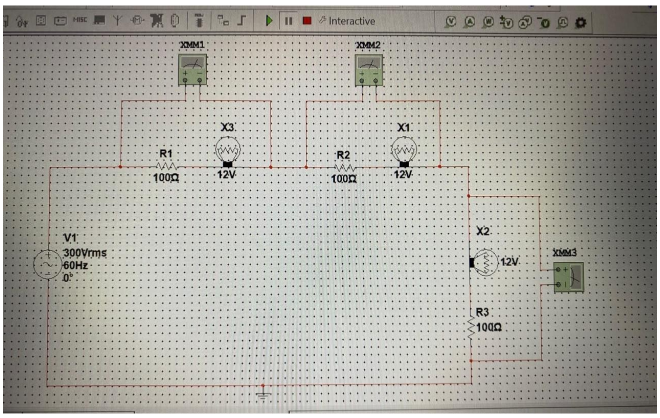

Fig. 3 Circuit configuration under a 300 V supply voltage before simulation.

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ISSN 3089-106X
(online)

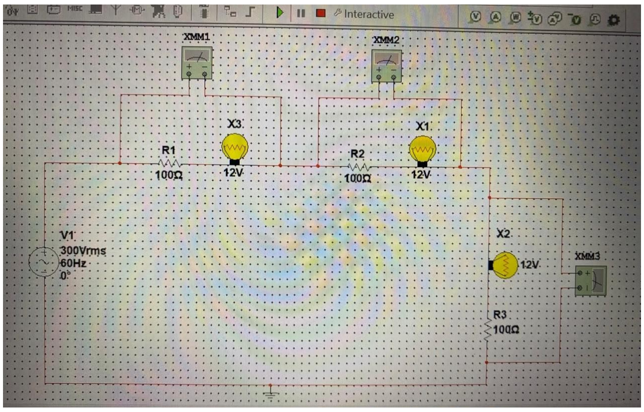

Fig. 4 Circuit configuration under a 300 V supply voltage after simulation.

When the supply voltage was increased to 320 V, the lamps failed and were no longer able to operate properly. This condition indicates that the applied voltage exceeded the operating limits of the components, resulting in load failure. Overall, the simulation results demonstrate a consistent change in the operating characteristics of the circuit as the supply voltage increased. A summary of the simulation results is presented in Table 1.

Table 1
Observation Results of the Series-Parallel AC Circuit Simulation

No	Supply Voltage (V)	Lamp Operating Condition
1	100 V	Off
2	130 V	Dimly Lit
3	170 V	Moderately Lit
4	200 V	Bright
5	220 V	Normal Brightness
6	240 V	Brighter
7	260 V	Very Bright
8	280 V	Near Maximum Brightness
9	300 V	Maximum Brightness
10	320 V	Lamp Failure

As presented in Table 1, the operating condition of the lamps changed progressively as the supply voltage increased. At lower voltage levels, the electrical energy delivered to the load was insufficient to produce visible illumination. Increasing the supply voltage resulted in progressively brighter lamp operation until the maximum brightness was observed at 300 V. When the voltage reached 320 V, the lamps failed, indicating that the applied voltage exceeded the operating limits of the simulated components.

The observed trend is consistent with the theoretical relationship described by Ohm's Law. Assuming the circuit resistance remains constant, increasing the supply voltage results in a proportional increase in electric current. Consequently, the electrical power supplied to the resistive load also increases, leading to higher light intensity. Although the present study did not quantitatively measure current or electrical power, the qualitative changes observed during the simulation are consistent with the expected electrical behavior of resistive loads under varying supply voltages.

The simulation results are also in agreement with previous studies. Hilma & Malik (2024) reported that increasing the supply voltage produced a proportional increase in electric current in simulation-based electrical experiments. Similarly, Putri et al, (2025)demonstrated that voltage variation significantly influences current flow and electrical power distribution in electrical circuits. Furthermore,)Malik et al (2020) explained that increasing electrical power supplied to resistive loads leads to higher light intensity until the operating limit of the component

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is exceeded. Therefore, although this study relied on qualitative observations of lamp operating conditions, the observed behavior is consistent with both established electrical theory and previously published findings.

It should be noted that the present study primarily relied on qualitative observations of lamp operating conditions rather than direct measurements of electrical parameters. Consequently, the interpretation of circuit behavior was based on established electrical theory and previous studies. Future investigations should incorporate quantitative simulation outputs, including electric current, voltage across individual components, electrical power, and power factor, to provide a more comprehensive evaluation of circuit performance and enable direct comparison with theoretical calculations.

DISCUSSIONS

The observed operating characteristics of the lamps are consistent with the theoretical principles of Ohm's Law, which states that, under constant resistance, an increase in the applied voltage results in a proportional increase in electric current. Consequently, the electrical power delivered to the resistive loads also increases, producing higher light intensity. Conversely, lower supply voltages reduce the electrical power delivered to the lamps, resulting in insufficient illumination or preventing the lamps from operating. Although the present study did not directly measure quantitative electrical parameters such as current and electrical power, the qualitative observations obtained from the simulation are consistent with the expected electrical behavior of resistive loads under varying supply voltage conditions.

The simulation findings are also supported by previous studies. Hilma and Malik (2024) demonstrated that increasing the supply voltage in simulation-based electrical experiments resulted in proportional increases in electric current, consistent with the theoretical prediction of Ohm's Law. Similarly, Putri et al. (2025) reported that variations in supply voltage significantly affect current distribution and electrical power within electrical circuits, thereby influencing the operating performance of connected loads. In addition, Malik et al. (2020) explained that increasing electrical power supplied to resistive loads enhances light intensity until the operating limits of the components are exceeded. The progressive increase in lamp brightness observed in this study therefore agrees with both established electrical theory and previous simulation-based investigations.

The lamp failure observed at 320 V indicates that the applied voltage exceeded the rated operating limit of the simulated electrical loads. This observation is consistent with the fundamental characteristics of resistive electrical components, in which excessive electrical power produces excessive heat generation and eventually leads to component failure. Although the present study relied on qualitative observations of lamp operating conditions rather than direct measurements of electrical parameters, the simulation successfully illustrates the influence of supply voltage variation on the overall operating characteristics of a series-parallel AC circuit.

Nevertheless, several limitations should be acknowledged. This study was conducted exclusively through computer simulation without experimental validation using physical hardware. Furthermore, quantitative electrical parameters such as electric current, voltage across individual components, electrical power, and power factor were not recorded during the simulation. Consequently, the interpretation of circuit behavior was primarily based on qualitative observations supported by established electrical theory and previous research. Future studies are recommended to incorporate quantitative simulation outputs together with experimental measurements to enable direct validation of simulation results under practical operating conditions.

CONCLUSION

This study investigated the effect of supply voltage variation on the operating characteristics of a series-parallel AC circuit using Multisim simulation. The simulation results suggest that increasing the supply voltage progressively changes the operating condition of the connected lamp loads, ranging from no illumination under low-voltage conditions to maximum brightness at higher voltages, followed by component failure when the applied voltage exceeded the operating limit. These observations are consistent with the theoretical relationships described by Ohm's Law and with previous studies reporting the influence of supply voltage on current distribution and electrical power delivered to resistive loads.

The findings indicate that Multisim provides a practical environment for the preliminary analysis of electrical circuit behavior under various operating conditions while reducing the risks associated with physical laboratory experiments. However, the conclusions of this study are limited to simulation-based observations and have not been validated through hardware implementation or experimental measurements. Therefore, the present findings should be interpreted as preliminary evidence of circuit behavior within the simulation environment rather than definitive validation of real-world electrical performance.

Future research should include quantitative electrical parameters such as electric current, voltage across individual components, electrical power, and power factor, together with experimental validation using physical electrical circuits. Such investigations would provide a more comprehensive evaluation of circuit performance and strengthen the agreement between simulation results, theoretical calculations, and practical implementation.

STATEMENT ON THE USE OF GENERATIVE AI

During the preparation of this manuscript, the authors used ChatGPT (GPT-5.5) developed by OpenAI solely to improve the grammar, sentence structure, clarity, and readability of the manuscript. Generative artificial intelligence was not used to generate, analyze, or interpret the research data, nor was it used to prepare the research findings or draw the scientific conclusions. All outputs generated by ChatGPT were carefully reviewed, verified, and thoroughly edited by the authors. The authors assume full responsibility for the accuracy, originality, and integrity of the submitted manuscript.

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