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(RESEARCH ARTICLE)

Electromagnetic frequency prediction pattern for electrical circuited shell based on FSTT theory using electromagnetic wave prediction method

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Abstract

This research focuses on electromagnetic analysis of electrical circuited shell to predict possible failure using wave prediction method. The equation is established considering axial and lateral hydrostatic pressure based on first order shear deformation theory of shell motion using the wave propagation approach and classic Flügge shell equations. For validation of accuracy of this research method, a comparison carried out with experimental data. With this method the effects of circuit parameters as well as different t power-law exponent on the frequencies are investigated. The results showed fantastic agreement between the present method and experimental ones.

Keywords: FSST Method; Wave propagation; Frequency prediction; Electromagnetic wave

1. Introduction

Electrical failure analysis is the process of identifying and diagnosing the root causes of electrical failures in various systems and components. Electrical failures can occur due to many factors, such as design flaws, manufacturing defects, environmental stress, human error, aging, corrosion, overload, or sabotage [1-3]. Electrical failure analysis can help determine the nature, extent, and impact of the failure, as well as provide recommendations for corrective and preventive actions. The trends of increasing structural complexity in devices and shrinking technology nodes go hand-in-hand with a higher risk of electrical defects, which are often more difficult to detect. Electrical Failure Analysis (EFA) bridges Electrical Characterization (nanoprobing) and Physical Failure Analysis. EFA aims to localize and identify design and fabrication faults, which can affect the yield, reliability and performance of semiconductor devices [4-8].

Electromagnetic prediction frequency patterns for electrical circuited shells are pivotal in modern technology, serving as the cornerstone for the design and optimization of various electronic systems and devices. This introduction will delve into the significance of understanding electromagnetic phenomena, the importance of predictive frequency patterns, and their application in electrical circuited shells [9-11].

Electromagnetic phenomena govern the behavior of electrically charged particles and the interaction between electric and magnetic fields. This fundamental aspect of physics underpins the operation of countless devices and systems, from household appliances to complex communication networks. Understanding electromagnetic phenomena is crucial for engineers and researchers seeking to design and optimize electronic circuits and devices for a wide range of applications.

Electrical circuited shells refer to structures that enclose electronic components or circuits, providing protection, shielding, and structural support. These shells can take various forms, ranging from simple enclosures to complex housings with intricate internal circuitry. Examples include the metal chassis of a computer, the casing of a mobile

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phone, or the housing of a satellite communication system. The design and optimization of electrical circuited shells are essential for ensuring the proper functioning and reliability of the enclosed electronics [12].

Predictive frequency patterns play a crucial role in the analysis and design of electrical circuited shells. These patterns provide insights into how electromagnetic waves propagate and interact with the shell structure across different frequencies. By understanding these patterns, engineers can predict potential interference, resonance phenomena, and other electromagnetic effects that may impact the performance of the enclosed electronics. Moreover, predictive frequency patterns allow for the optimization of the shell design to minimize electromagnetic interference (EMI) and ensure electromagnetic compatibility (EMC) with other nearby devices and systems [13].

The applications of predictive frequency patterns for electrical circuited shells are diverse and far-reaching. In the telecommunications industry, for example, understanding the frequency-dependent behavior of antenna enclosures is essential for designing efficient and reliable communication systems. Similarly, in the automotive sector, predictive frequency patterns are used to optimize the electromagnetic shielding of electronic control units (ECUs) to prevent interference from external sources such as radio frequency (RF) signals or electromagnetic pulses (EMP). In the aerospace industry, predictive frequency patterns are employed to design satellite payloads and onboard electronics that can withstand the harsh electromagnetic environment of space [14-16].

Wave propagation methods enable engineers to model and simulate electromagnetic wave behavior within electrical circuited shells accurately. By simulating wave propagation, engineers can predict how electromagnetic waves interact with the shell structure, identifying areas of potential interference or resonance. This predictive capability allows for the optimization of shell design parameters, such as material properties, geometry, and layout, to achieve desired electromagnetic performance characteristics.

2. Methodology

The applications of predictive frequency patterns derived from wave propagation methods are diverse and expansive. In the telecommunications industry, understanding the frequency-dependent behavior of antenna enclosures is crucial for designing efficient and reliable communication systems. Similarly, in the automotive sector, predictive frequency patterns are utilized to optimize the electromagnetic shielding of electronic control units (ECUs) against interference from external sources like radio frequency (RF) signals or electromagnetic pulses (EMP). In the aerospace industry, predictive frequency patterns aid in designing satellite payloads and onboard electronics capable of withstanding the harsh electromagnetic environment of space.

WP methods provide a powerful framework for understanding electromagnetic phenomena and predicting frequency patterns crucial for the design and optimization of electrical circuited shells. By leveraging these methods, engineers can develop robust and reliable electronic systems and devices across various industries, ensuring optimal electromagnetic performance and compatibility [17-20].

3. Experimental procedure

Gathering data equipment for examining effectiveness of this method are Multimeter, Oscilloscope, Signal Generator, Safety Equipment. Disconnect the circuit from the power source and ensure proper safety measures are in place.

the circuit visually for damage or anomalies should be done visually to identify: any signs of burnt components, corrosion, or physical damage. Any abnormalities such as loose connections or solder joints should be addressed carefully.

3.1. Continuity Testing

Use the multimeter to check for continuity across connections Test each connection point for continuity to ensure there are no open circuits. Verify continuity through resistors, capacitors, inductors, and interconnects.

3.2. Record resistance values

- Resistor R1: 470 ohms. Resistor R2: 220 ohms. Capacitor C1: No resistance (as expected).
- Inductor L1: 100 mH.
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3.3. Voltage Testing

Connect the circuit to power and measure voltages using the oscilloscope. Measure voltages at critical nodes and components:

Voltage at Node A: 12V, Voltage at Node B: 5V, Voltage at Node C: 3V. Verify voltage levels against expected values.

3.4. Signal Injection

Inject test signals using the signal generator and observe the response on the oscilloscope, Test different frequencies and waveforms:1 kHz sine wave injected at Node D.

Monitor waveform integrity and amplitude.

Thermal Imaging: Use a thermal imaging camera to detect hotspots and abnormal temperature distributions: Scan the circuit for areas of elevated temperature. Identify components or connections that may be overheating.

3.5. Isolation Testing

Disconnect segments of the circuit and test independently:

Isolate input and output sections, as well as individual components: Disconnect input segment: No change in behavior. Disconnect output segment: No change in behavior.

Figure 1 shows experimental arrangement of nodes in circuit and measurement instrument for these experiments. Measuring for different nodes is shown in figure 2. Figure 3 shows 80 different nodes and one result for frequency of mode 4 is shown in figure 4.

Figure 1 Electrical shell shaped circuit and measuring frequency instrument

Figure 2 Practical measurement during experiments

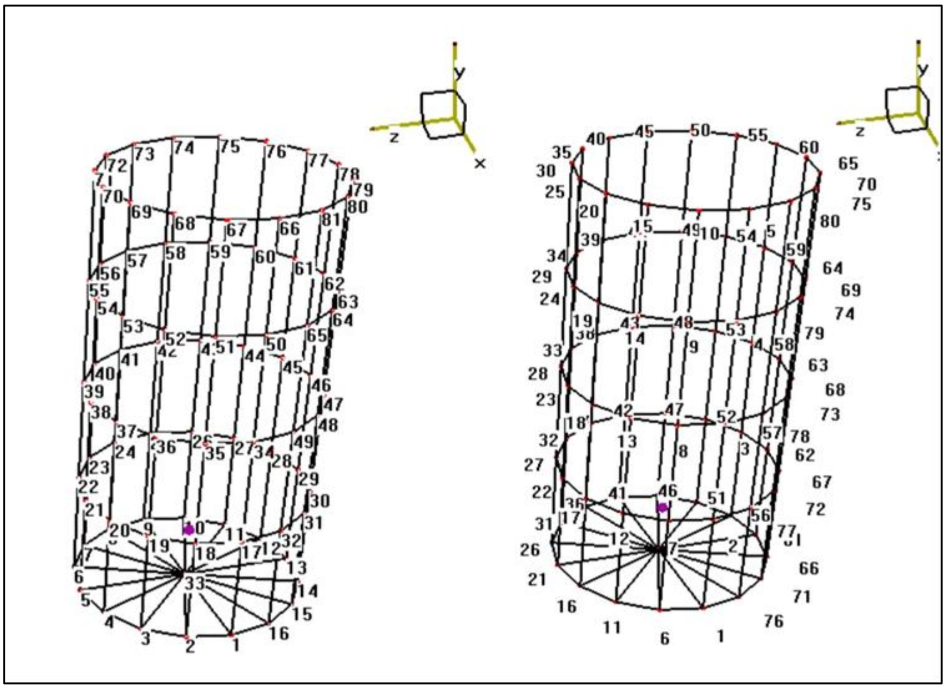

Figure 3 Measuring 80 different nodes and determining them for WP method

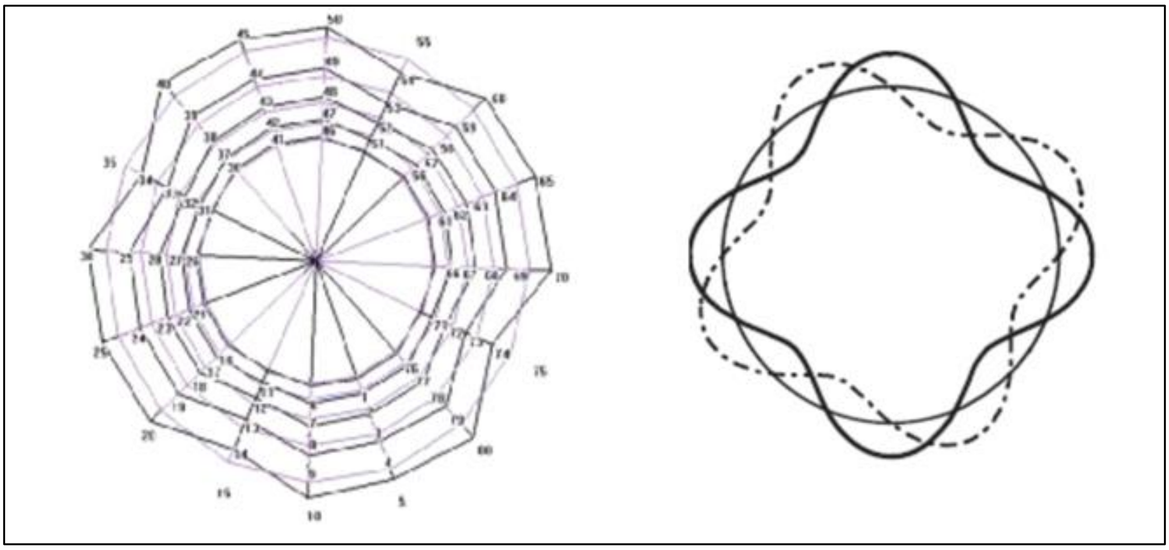

Figure 4 Measuring 80 different nodes and determining them for WP method

4. Results and discussion

This comprehensive procedure provides a detailed and systematic approach for identifying faults in a complex electrical shell-shaped circuit, involving thorough testing, analysis, and documentation. Results of experimental analysis are shown in figure 5. It is clear from the results that circuit 2 and 10 are faulty that completely align with WP method.

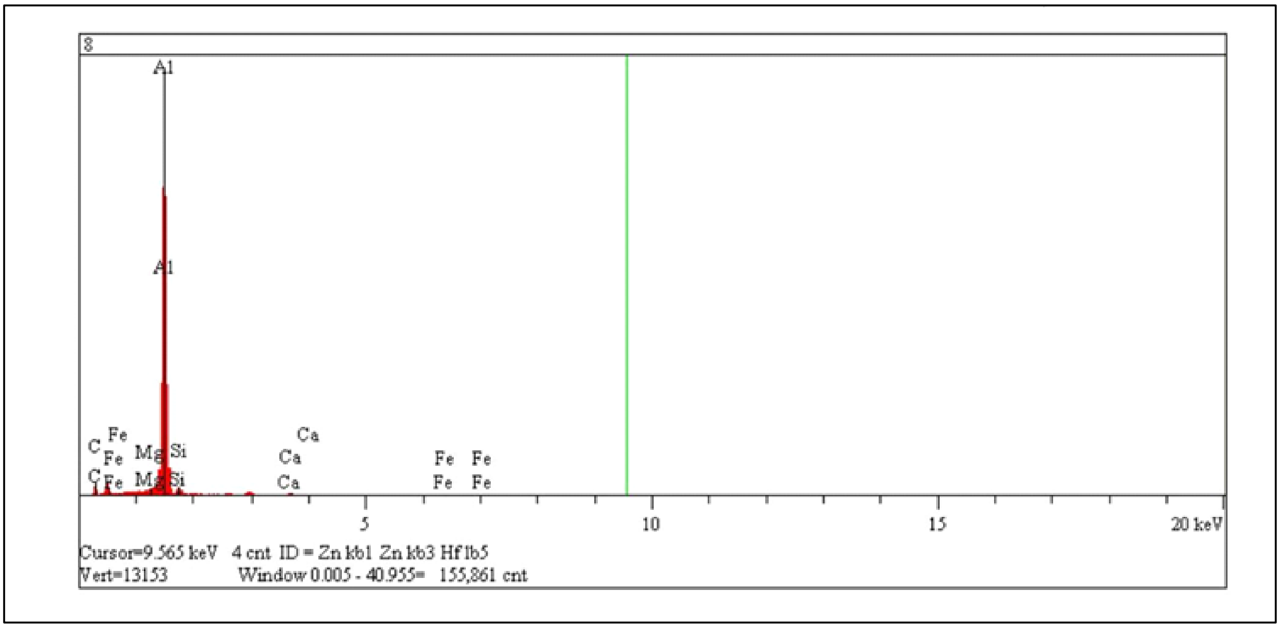

Figure 5 Experimental results of WP method for distinguishing failure

5. Conclusion

This research demonstrates the effectiveness of using electromagnetic wave prediction methods, combined with the first-order shear deformation theory (FSTT), to analyze and predict frequency behavior in electrical circuited shells. The study shows strong agreement between theoretical predictions and experimental results, confirming the accuracy of this approach in identifying potential circuit failures and electromagnetic interference issues.

Through a systematic experimental process, including voltage testing, continuity checks, and signal injections, this method proves to be a practical tool for diagnosing faults in electrical circuits. The results indicate that predictive frequency patterns can be reliably used to detect failures, as seen with circuits 2 and 10.

Overall, the findings highlight the potential of this method for optimizing the design and conclusion: performance of electronic systems, making it valuable for applications in industries like telecommunications, automotive, and aerospace.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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