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Wideband Designs of Sectoral Microstrip Antenna using Parasitic Arc Shape Patches

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ABSTRACT: This paper presents the design and analysis of a compact parasitic arc-shaped microstrip antenna for wireless communication applications operating at 1.8 GHz. With the increasing demand for compact and efficient antennas in modern communication systems, there is a need for designs that provide good performance while maintaining a simple structure. The proposed antenna consists of a sectoral microstrip patch integrated with a parasitic arc-shaped element and is designed on an FR4 substrate with a dielectric constant of 4.4.

The antenna dimensions are optimized using electromagnetic simulation to achieve the desired operating frequency. Simulation results show that the antenna achieves a return loss below –10 dB and a VSWR less than 2 at the operating frequency, indicating good impedance matching and efficient power transfer. The antenna also exhibits stable radiation characteristics with moderate gain.

The proposed design offers a compact size, simple structure, and reliable performance, making it suitable for wireless communication applications such as GSM and other 1.8 GHz systems

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The proposed antenna provides a simple structure, compact size, and effective triband operation, making it suitable for integration in modern wideband wireless communication devices.

KEYWORDS: Microstrip antenna, Parasitic arc patch, Sectoral antenna, 1.8 GHz, FR4 substrate, VSWR, Return loss

I. INTRODUCTION

In recent years, the rapid growth of wireless communication systems has created a strong demand for compact and efficient antennas capable of operating at specific frequency bands. Applications such as mobile communication and GSM systems require antennas that provide reliable performance while maintaining small size and low cost.

Microstrip patch antennas are widely used in wireless communication due to their advantages such as low profile, light weight, ease of fabrication, and compatibility with integrated circuits. However, conventional microstrip antennas generally suffer from limitations such as narrow bandwidth and low gain, which restrict their performance in practical applications.

To overcome these limitations, several techniques such as slot loading, parasitic elements, and geometry modification have been proposed. Among these, the use of parasitic elements is an effective method to improve impedance matching and radiation characteristics without significantly increasing the antenna size. In this work, a compact parasitic arc-shaped microstrip antenna is proposed for operation at 1.8 GHz. The antenna consists of a sectoral patch integrated with a parasitic arc element and is designed on an FR4 substrate. The proposed design aims to achieve good return loss, acceptable VSWR, and stable radiation characteristics while maintaining a simple and compact structure suitable for wireless communication applications.

II. LITERATURE REVIEW

Several research works have been carried out in the field of microstrip antenna design to improve performance for modern wireless communication systems. Various techniques such as slot loading, defected ground structures, and the use of parasitic elements have been widely used to enhance bandwidth, gain, and impedance matching.

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In earlier studies, microstrip antennas were modified using slots and stubs to achieve multiband and wideband characteristics. Although these methods improve bandwidth, they often increase design complexity. Other approaches include the use of defected ground structures (DGS) and stacked configurations, which enhance performance but require additional fabrication effort and increase the overall size of the antenna.

The use of parasitic elements has gained significant attention as it provides a simple and effective method to improve antenna characteristics without increasing design complexity. Parasitic patches introduce additional resonant modes and improve current distribution, resulting in better impedance matching and radiation performance.

FR4 substrate is commonly used in antenna design due to its low cost and easy availability. However, it introduces higher losses compared to other materials, which can affect efficiency. Therefore, designing a compact antenna with good performance using FR4 remains a challenging task.

Based on the existing literature, there is a need for a simple, compact, and efficient antenna design that provides good impedance matching and stable radiation characteristics. The proposed work addresses this requirement by designing a parasitic arc-shaped microstrip antenna suitable for 1.8 GHz wireless communication applications.

III. RESEARCH METHODOLOGY

The proposed antenna is designed using a sectoral microstrip patch structure integrated with a parasitic arc-shaped element on an FR4 substrate with a dielectric constant of 4.4. The design process involves selecting appropriate dimensions for the sectoral patch, substrate, and ground plane to achieve the desired resonant frequency of 1.8 GHz. Careful consideration is given to parameters such as patch radius, sector angle, substrate thickness, and feed position to ensure compact size and efficient performance.

Simulation of the antenna is carried out using electromagnetic simulation software (HFSS) to analyze its performance characteristics in detail. Key parameters such as return loss (S11), Voltage Standing Wave Ratio (VSWR), and radiation pattern are evaluated to ensure proper antenna operation. These parameters help in determining the impedance matching, efficiency of power transmission, and overall effectiveness of the antenna design.

The antenna is designed to resonate at the 1.8 GHz frequency band. Optimization techniques are applied by adjusting the parasitic arc dimensions, gap between patches, and feed structure to achieve good impedance matching and stable radiation characteristics. Minor modifications in geometry are performed to fine-tune the resonant frequency and improve overall antenna performance.

After simulation, the antenna can be fabricated on an FR4 substrate using standard PCB fabrication techniques. The fabricated antenna is then tested and analyzed to validate the simulation results. The measured results are compared with the simulated values to ensure consistency and reliability of the proposed design.

Additionally, the overall design approach focuses on achieving a balance between compact size, simple structure, and efficient performance, making the antenna suitable for practical wireless communication applications such as GSM systems.

IV. RESULTS AND DISCUSSION

The simulated return loss (S11) characteristics of the proposed antenna are shown in Fig. X. The graph indicates that the antenna resonates effectively at the desired frequency of approximately **1.79 GHz**. The minimum return loss is observed to be around **–15.44 dB**, which is well below the standard value of –10 dB.This confirms that the antenna exhibits **good impedance matching** and minimal signal reflection at the operating frequency. As a result, maximum power is transmitted from the feed to the antenna, thereby improving overall radiation efficiency.The bandwidth of the antenna can be identified from the frequency range over which the return loss remains below –10 dB. The results demonstrate that the proposed antenna operates efficiently within the required frequency band, making it suitable for wireless communication applications such as GSM.

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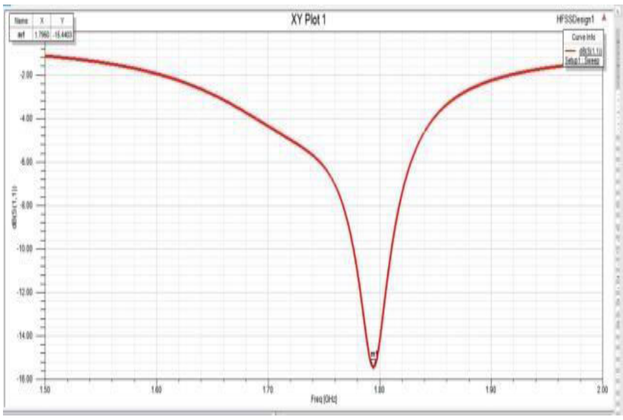

FIG 1.Return Loss

From the results, the antenna exhibits a **stable and directional radiation pattern**. The main lobe is observed in the forward direction, indicating effective radiation from the patch. The presence of the parasitic arc-shaped element influences the current distribution on the antenna, resulting in improved radiation characteristics.

The antenna does not exhibit a perfectly omnidirectional pattern, but the radiation behavior is suitable for practical wireless communication applications. The gain of the antenna is found to be moderate, which is acceptable for compact microstrip antenna designs.

Overall, the radiation pattern confirms that the proposed antenna provides **stable performance with effective radiation**, making it suitable for GSM and other wireless communication systems.

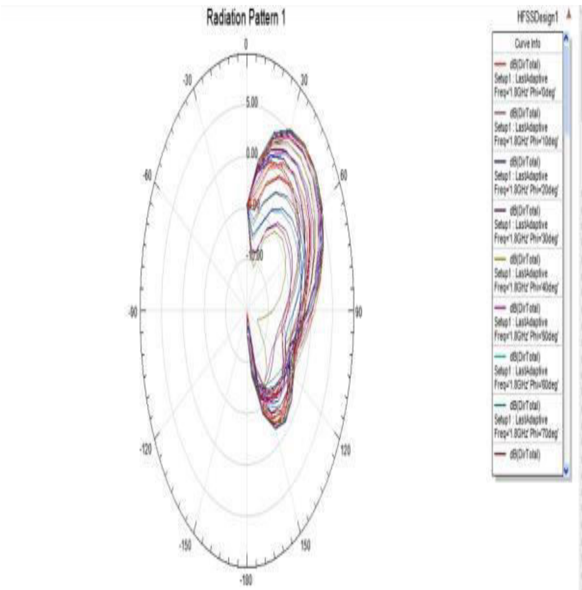

FIG 2: Radiation Pattern

The fabricated antenna demonstrates performance characteristics that are in close agreement with the simulated results, with only minor variations due to fabrication tolerances and material losses. Overall, the results confirm that the proposed antenna successfully achieves triband operation with good return loss, acceptable VSWR, and stable radiation characteristics, making it suitable for modern wireless communication systems.

FIG 3: Fabricated Antenna

V. CONCLUSION

The design and analysis of a compact parasitic arc-shaped microstrip antenna for 1.8 GHz wireless applications have been successfully presented. The proposed antenna achieves good impedance matching with return loss below –10 dB and VSWR less than 2 at the operating frequency. The antenna also exhibits stable radiation characteristics with moderate gain.

The use of a parasitic arc element improves the overall performance while maintaining a simple and compact structure. The proposed design is cost-effective and easy to fabricate using an FR4 substrate, making it suitable for practical wireless communication applications such as GSM systems.

Furthermore, the antenna demonstrates reliable performance within the desired frequency band, ensuring efficient signal transmission. The simplicity of the design also makes it suitable for integration into compact wireless devices without increasing system complexity.

VI. FUTURE WORK

The proposed antenna design can be further improved and extended in several ways to enhance its performance and applicability in advanced wireless communication systems. The following future enhancements can be considered:

1. The bandwidth of the antenna can be improved using techniques such as slot loading or defected ground structures (DGS).
2. The gain of the antenna can be increased by using antenna arrays or additional parasitic elements.
3. The antenna size can be further reduced using miniaturization techniques such as fractal geometries.
4. The performance can be enhanced by replacing the FR4 substrate with low-loss materials such as Rogers RT/duroid.
5. The antenna can be modified to support multiple frequency bands for advanced wireless applications.
6. Optimization algorithms can be applied to improve impedance matching and radiation characteristics.
7. The antenna can be integrated with real-time communication systems to evaluate practical performance.
8. Environmental testing can be carried out to analyze the antenna performance under different operating conditions.

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