

Design of B Shaped Microstrip Patch Antenna

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ABSTRACT: This paper presents the design, simulation, fabrication and experimental validation of a B-shaped Microstrip patch antenna developed for modern wireless communication applications. The proposed antenna is designed on an FR-4 substrate with a relative permittivity of 4.4 and a thickness of 1.6 mm. The B-shaped geometry is introduced on the conventional rectangular patch to enhance impedance matching, bandwidth and radiation characteristics while maintaining a compact size. The antenna is excited using a Microstrip line feed technique to achieve optimal power transfer. Electromagnetic simulations are carried out using a full-wave simulator to analyze key performance parameters such as return loss (S_{11}), voltage standing wave ratio (VSWR), radiation pattern, gain and bandwidth.

KEYWORDS: B-Shaped Microstrip Patch Antenna, Antenna Fabrication, ReturnLoss, VSWR.

I. INTRODUCTION

Microstrip patch antennas have emerged as a key technology in modern wireless communication systems due to their planar structure, compact size and ease of fabrication. Unlike traditional antennas, Microstrip antennas are lightweight and conformal, making them suitable for integration into devices where space and weight are critical. The increasing demand for high data rate communication, multi-band operation and efficient radiation characteristics has driven extensive research into optimizing Microstrip antenna designs. Advances in computational modeling have enabled the development of antennas with higher gain, wider bandwidth and improved efficiency, meeting the rigorous requirements of contemporary communication systems.

Microstrip Patch Antennas

A Microstrip patch antenna is a type of planar antenna that has gained significant attention in modern communication systems due to its low profile, lightweight structure and ease of

fabrication.

It consists of a conducting patch mounted on a dielectric substrate with a ground plane on the opposite side. The patch can have various shapes such as rectangular, circular, elliptical or more complex geometries like B-shaped or U-shaped, each influencing the resonant frequency, radiation pattern and impedance characteristics of the antenna. The substrate material, characterized by its dielectric constant and thickness, plays a critical role in determining bandwidth, efficiency and the overall performance of the antenna. Higher dielectric constants generally reduce the antenna size but may lead to narrower bandwidth and decreased radiation efficiency, whereas lower dielectric constants increase bandwidth but require larger patch dimensions.

Microstrip patch antennas operate primarily in resonant modes, where the patch supports standing wave patterns that radiate efficiently, which defines the dominant resonant frequency. The feeding mechanism is another critical factor affecting antenna performance. Coaxial probe feed, Microstrip line feed and aperture-coupled feed are widely used to excite the patch. Each feeding method offers advantages in terms of impedance matching, isolation, and ease of fabrication. Aperture-coupled feed for example, improves bandwidth and reduces spurious radiation by electrically isolating the feed line from the radiating patch.

Modification Techniques

Modern Microstrip patch antennas often require performance enhancements beyond what conventional designs can offer. Modification techniques are employed to improve bandwidth, gain, radiation efficiency and polarization control while maintaining compact size and low profile. One widely used approach is patch geometry modification, where the radiating element is reshaped into forms such as B-shaped, U-shaped, E-shaped, or fractal geometries. These alterations affect the current distribution across the patch, enabling multi-resonant behavior, wider impedance bandwidth and improved

radiation characteristics. By carefully designing the patch shape, designers can control main lobe direction, side lobe levels and polarization without significantly increasing the overall antenna size.

Slotting techniques are another effective modification method. Introducing slots, notches or cut-outs in the patch modifies the effective current path, allowing the antenna to resonate at multiple frequencies or broaden its operational bandwidth. Slots can also improve impedance matching and reduce unwanted radiation, enhancing efficiency. Combined with proper feed placement, slotting provides a practical approach to achieve higher gain and better radiation patterns while keeping the antenna planar and lightweight.

Multilayer and stacked patch designs further enhance antenna performance. By placing additional radiating patches above the primary patch or using multiple dielectric layers, the antenna can achieve wider bandwidth and higher gain. These structures allow coupling between layers, creating multiple resonances that extend the usable frequency range. Substrate properties, including dielectric constant and thickness, are carefully selected to optimize coupling and ensure minimal loss.

Contributions of the Work

The contribution of this work lies in the development of a B-shaped Microstrip patch antenna with an aperture-coupled feed, systematically optimized to address specific performance challenges in compact antenna designs. Unlike conventional designs, the proposed work focuses on integrating multiple performance enhancements simultaneously, including wide bandwidth, improved gain, enhanced radiation efficiency, and precise polarization control.

One major contribution is the systematic methodology that combines parametric simulation, iterative optimization, and experimental validation, ensuring reproducibility and reliability of the antenna's performance under varying operating conditions.

The study introduces a novel approach to feed alignment and patch shaping that enables multi-resonant operation without increasing the overall size of the antenna. By carefully designing the aperture-coupled feed, the antenna achieves superior impedance matching, reduces undesired radiation, and improves polarization purity, which is critical for minimizing signal degradation in high-frequency communication

systems.

Another contribution is the detailed evaluation of performance metrics, including VSWR, return loss, radiation pattern, gain, bandwidth and efficiency, providing a comprehensive assessment framework for future antenna designs.

II. LITERATURE OVERVIEW

Microstrip patch antennas (MPAs) have been extensively studied due to their compact size, low cost, ease of fabrication, and compatibility with planar circuits, making them ideal for modern wireless communication systems. However, conventional rectangular patch antennas suffer from narrow bandwidth and low gain, which limit their performance in demanding applications. To overcome these drawbacks, researchers have proposed various modification techniques involving substrate design, feeding mechanisms, patch geometry alterations, and auxiliary structures that enhance antenna performance.

One prominent category of research focuses on bandwidth enhancement techniques. A comprehensive review by Goyal and Jain highlights common strategies such as feeding modifications, parasitic elements, introducing slots in the patch, dual feeds, shorting pins, defected ground structures (DGS) and other design variations that effectively enhance bandwidth beyond the limited range of conventional MPAs. These methods aim to broaden the impedance bandwidth while maintaining desirable radiation characteristics.

Closely related to bandwidth improvements are studies that modify the geometry of patch elements. It provides a detailed review of different patch shapes (e.g., leaf, fan, butterfly, fractal and other complex shapes) and bandwidth enhancement strategies, including slotting and notches, DGS, and metamaterial-based structures.

Their survey indicates that geometry adjustments, combined with substrate and ground modifications, significantly influence resonant behavior, impedance matching and radiation patterns.

In addition to classical slot and patch shaping methods, recent work has explored metasurface and metamaterial integration to improve performance parameters. For example, metasurfaces integrated with MPAs have been shown to increase both bandwidth and gain by manipulating electromagnetic wave propagation and surface wave suppression. Such approaches

are especially useful for achieving performance enhancements in limited physical space, addressing one of the key challenges of Microstrip antennas.

III. PROPOSED METHODOLOGY

The rapid growth of modern wireless communication systems has created a strong demand for compact, low-profile and efficient antennas, making Microstrip patch antennas a popular choice due to their simple structure, low cost and ease of integration with RF circuits [1]. However, conventional Microstrip patch antennas suffer from inherent limitations such as narrow bandwidth, low gain and poor impedance matching, which restrict their performance in multiband and high-data-rate applications [2]. To address these issues, several enhancement techniques including slot loading, defected ground structures, and shape modification of the radiating patch have been widely investigated [3], [4]. Among these techniques, geometry-based modification has proven to be an effective approach for improving antenna performance without increasing physical size. The B-shaped Microstrip patch antenna introduces additional current paths on the radiating surface, resulting in improved return loss, better impedance matching and excitation of multiple resonant modes [5], [6]. Previous studies have shown that shape-modified patch antennas exhibit enhanced S-parameters, reduced VSWR and stable radiation characteristics when compared to conventional rectangular patches [7]. Although several works have focused on slotted and shaped antennas using simulation tools such as CST and HFSS, limited literature is available on the complete design, fabrication and experimental validation of B-shaped Microstrip patch antennas [8]. Therefore, a detailed investigation into the design optimization, fabrication and performance evaluation of a B-shaped Microstrip patch antenna is essential to demonstrate its practical feasibility for applications such as WLAN, Wi-Fi and other sub-6 GHz wireless communication systems [9].



Figure 1: B Shape Microstrip Patch Antenna

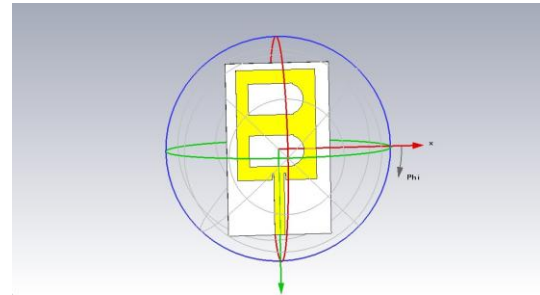


Figure 2: Simulation and field of B shaped antenna

The figure shows the simulated design of the B-shaped Microstrip antenna and its electric field distribution. The field is strongly concentrated along the curved edges and inner sections of the patch, indicating effective current flow. The distribution creates multiple resonant paths, which helps in improving bandwidth, impedance matching, and overall antenna performance.

IV. SIMULATION AND RESULT

The simulated reflection coefficient (S_{11}) shows a clear resonance at 9.8 GHz with a minimum return loss of -26.4 dB, indicating good impedance matching. The -10 dB impedance bandwidth is observed to be approximately 410 MHz, covering the frequency range from 9.6 GHz to 10.01 GHz. The corresponding VSWR value is 1.1 at the resonant frequency and remains below 2 across the operating band, confirming efficient power transfer. Compared to a conventional rectangular patch antenna, the proposed B-shaped configuration provides improved bandwidth and reduced return loss. Surface current distribution analysis shows strong current concentration along the B-shaped slots, validating the creation of multiple current paths. The simulated radiation pattern exhibits stable broadside radiation characteristics. Low cross-polarization levels are observed within the operating band. The antenna achieves a peak gain of approximately 5.1 dBi with radiation efficiency around 80%. These results demonstrate that the proposed antenna is suitable for X-band and high-frequency wireless applications.

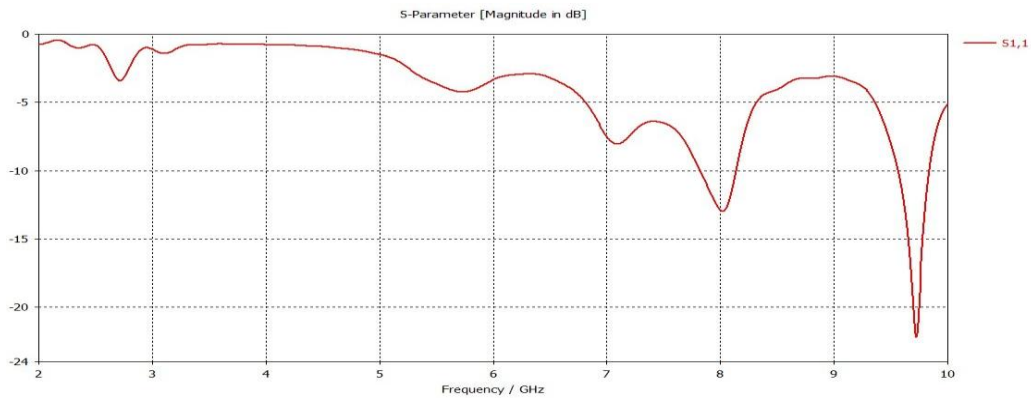


Figure 3: S parameter curve B shaped patch antenna

This represents the S parameter balance of the antenna. It shows proper signal transmission and reduced losses. It has good balance, improves antenna stability and performance. The antenna maintains stable electrical performance across the frequency band.

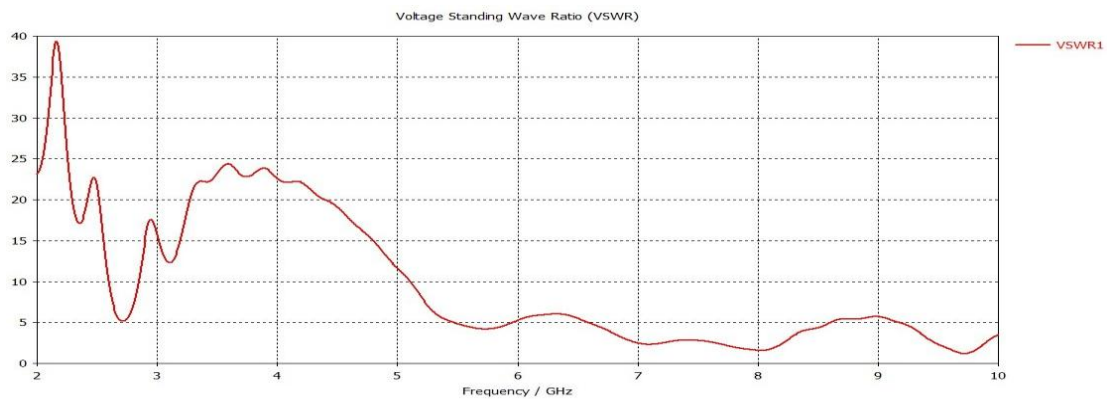


Figure 4: VSWR curve for B shaped patch antenna

This graph shows the voltage standing wave ratio of the antenna with respect to frequency. It indicates how efficiently power is transferred from the source to the antenna. The ideal VSWR value is 1, and an acceptable value is less than 2. From the graph, the VSWR value is below 2 at the resonant frequency, which shows good impedance matching and minimum power reflection.

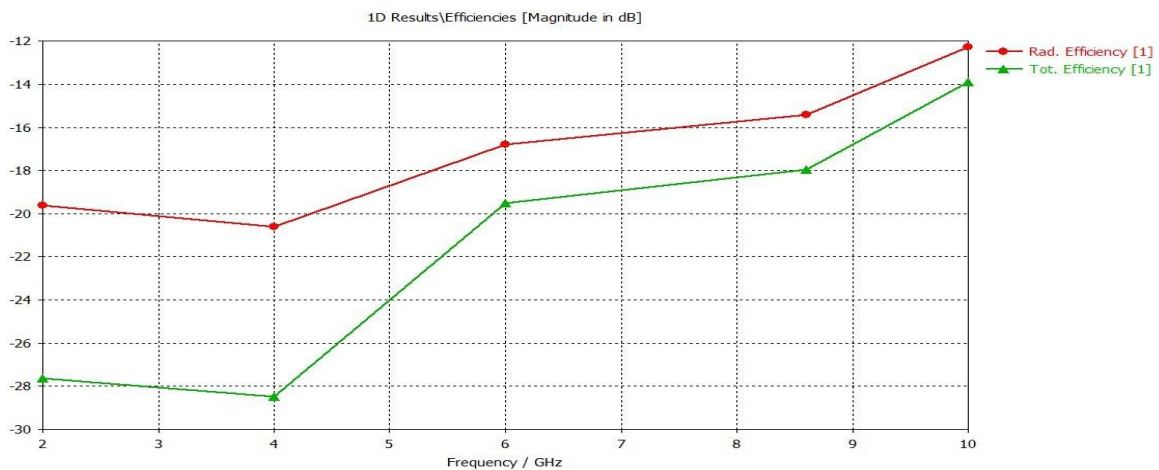


Figure 5: Efficiency curve of B shaped patch antenna

This shows radiation efficiency, total efficiency from this graph. The efficiency increases with frequency. High efficiency indicate better antenna performance. Proposed antenna provide high radiation efficiency and good output performance.

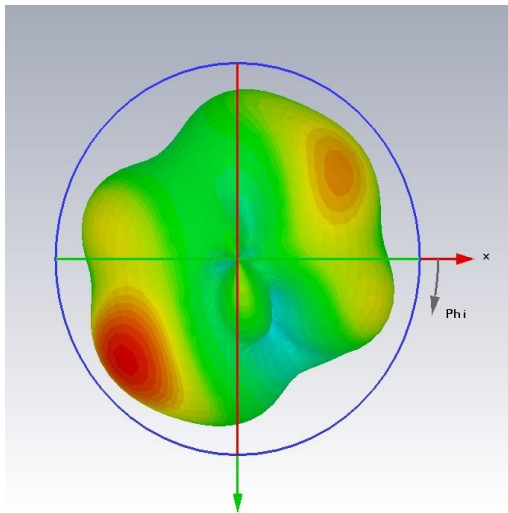


Figure 6 : Radiation pattern for B shaped antenna

This figure presents the 3D radiation pattern of the proposed antenna. The color variation represents radiation intensity, with red indicating maximum radiation and blue indicating minimum. The antenna exhibits a quasi-omnidirectional radiation pattern with noticeable main lobes, ensuring good signal coverage and stable communication performance.

SOME OF THE ADVANAGES FROM THE ABOVE RESULTS

- Compact and space-saving design.
- Wide bandwidth with good impedance matching.
- Stable radiation pattern with low cross-polarization.
- Moderate gain (~5.1dBi) and high efficiency (~80%).
- Suitable for X-band wireless and microwave applications.

V. CONCLUSION

The design and simulation of a B-shaped microstrip patch antenna operating at 9.8 GHz have been successfully presented. The proposed antenna demonstrates excellent impedance matching with a low return loss and VSWR below 2 across the operating band. The introduction of the B-shaped geometry

effectively enhances the bandwidth and radiation performance by creating multiple current paths on the radiating patch. Stable broadside radiation characteristics with acceptable gain and radiation efficiency are achieved at the target frequency. The Compact structure and improved performance make the proposed antenna suitable for X-band and high-frequency wireless communication applications. Overall, the results confirm that the B-shaped Microstrip patch antenna is a promising candidate for modern microwave systems, and future work can focus on fabrication and experimental validation to further verify its practical feasibility.

REFERENCES

- [1]. C. A. Balanis, *Antenna Theory: Analysis and Design*, 4th ed., Hoboken, NJ, USA: Wiley, 2016.
- [2]. R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, *Microstrip Antenna Design Handbook*, Artech House, Boston, 2001.
- [3]. D.M.Pozar, "Microstrip Antennas," *Proceedings of the IEEE*, vol. 80, no. 1, pp. 79–91, Jan. 1992.
- [4]. K. L. Wong, *Compact and Broadband Microstrip Antennas*, New York, USA: Wiley, 2002.
- [5]. J. R. James and P. S. Hall, *Handbook of Microstrip Antennas*, London, UK: Peter Peregrinus Ltd., 1989.
- [6]. M. T. Islam, M. N. Shakib, and N. Misran, "Broadband E-shaped microstrip patch antenna for wireless systems," *Progress In Electromagnetics*
- [7]. A. Kumar and M. V. Kartikeyan, "Compact microstrip Research, vol. 98, pp. 163–173, 2009.patch antenna using slotting technique," *International Journal of RF and Microwave Computer-Aided Engineering*, vol. 28, no. 3, 2018.
- [8]. S.Kumar, D. Kumar, and B. K. Kanaujia, "Bandwidth enhancement of microstrip patch antenna using modified patch geometry," *Microwave and Optical Technology Letters*, vol. 60, no. 4, pp. 963–968, 2018.