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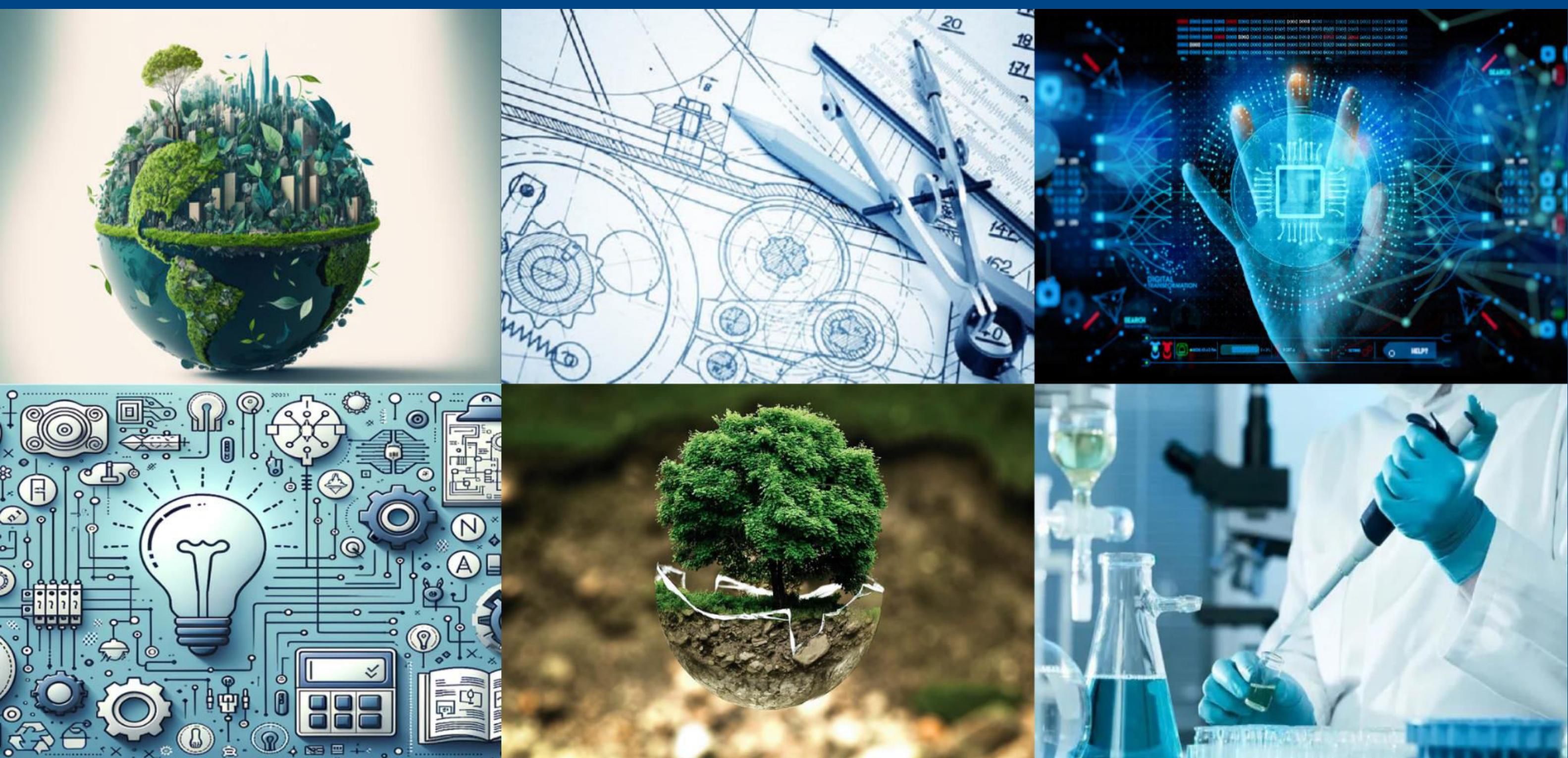

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Design of C Band Stacked Patch Microstrip Antenna Array

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ABSTRACT: The proposed antenna design is a dual frequency stacked patch antenna tailored for a C band (4 GHz to 8 GHz) application, specifically targeting frequencies of 5.2GHz and 5.8GHz, which are commonly used in wireless communication system such as Wi-Fi (IEEE 802.11ac) and fixed wireless access (FWA). The antenna employs a stacked patch configuration to achieve dual frequency operation, enhancing bandwidth and gain crucial for high-speed data transmission and reliable connectivity. The lower patch is designed for operation at 5.2GHz while the upper patch resonating at 5.8GHz, is stacked above the lower patch with a dielectric substrate to optimize coupling and radiation efficiency. The selected substrate material is FR 4 with dielectric constant 4.4 the antenna is fed via a coaxial probe that excite the lower patch directly, with the upper patch receiving energy through electromagnetic coupling. This feeding method ensures efficient energy transfer while maintain the compactness of the antenna design. The antenna design process utilizes the CST software to model and optimize the electromagnetic performance. Simulation results like directivity, input impedance, radiation pattern (2D and 3D), gain, axial ratio, return loss and VSWR of the antenna will be analysed using CST software.

KEYWORDS: Return loss, High gain, S-Parameters, Stacked array antenna, VSWR, Directivity, CST.

I. INTRODUCTION

Modern wireless communication systems, including Wi-Fi and other broadband services, require antennas that are compact, efficient, and capable of operating at multiple frequencies. The C-band spectrum, specifically within the range of 4 GHz to 8 GHz, is increasingly used due to its balance between range and bandwidth, making it ideal for applications like IEEE 802.11ac (Wi-Fi 5), 5G, and fixed wireless access (FWA). However, traditional microstrip patch antennas often suffer from limited bandwidth and low gain, making them less suitable for high-performance wireless systems.

To address these limitations, researchers and engineers have developed various techniques, among which the stacked patch configuration has proven particularly effective. This method involves placing one or more radiating patches above each other, separated by dielectric materials. The stacking not only enables dual or multi-frequency operations but also significantly enhances the antenna's bandwidth and gain. The improved coupling and radiation characteristics make stacked antennas ideal for compact and high-efficiency wireless systems.

This paper presents the design and analysis of a 2x2 stacked microstrip patch antenna array operating at two key C-band frequencies, 5.2 GHz and 5.8 GHz. These frequencies are selected to cover major Wi-Fi applications, offering a solution that combines simplicity in design with performance enhancements made possible through stacking. The use of a 2x2 array configuration further improves the overall antenna gain and radiation characteristics, making it suitable for applications requiring directional transmission and high efficiency. CST Studio Suite is employed for the simulation, enabling precise modeling and analysis of electromagnetic behavior. The antenna uses a coaxial probe feed to excite the lower patch, a method known for its low spurious radiation and good impedance matching. The goal is to

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deliver a design that meets the stringent requirements of modern wireless applications while remaining practical for fabrication**.**

II. LITERATURE SURVEY

In recent years, microstrip patch antennas have become integral to modern wireless communication systems owing to their low-profile, lightweight design and compatibility with integrated circuits. Despite these advantages, conventional patch antennas face limitations in bandwidth, gain, and polarization purity. To address these challenges, researchers have explored **stacked microstrip antenna architectures**, which offer enhanced bandwidth and circular polarization capabilities.

1.Shekhawat et al[1]: proposed a single-feed stacked rectangular patch structure, which significantly improved both the axial ratio and impedance bandwidth. Their design achieved an axial ratio bandwidth of over 11% and an impedance bandwidth exceeding 27%, facilitated by optimized corner truncation and slot placement

2.Jayasri and Daniel[2]: explored a stacked antenna operating in the 4–10 GHz C-band, using parametric analysis to determine inter-element effects. Their design supports wideband response with multiple resonances and gains suitable for Wi-Fi, ISM, and weather radar systems

3.Tiwari et al[3]: analyzed microstrip patch arrays and emphasized performance parameters such as return loss, VSWR, and gain. Their work supports the adoption of microstrip arrays in both low and high-frequency bands essential for emerging mobile infrastructure

4.Nagaraju and Kumaraswamy[4]: utilize a 3x3 stacked array with dual cross polarization for reconfigurability. Operating in the 4.9–5.9 GHz band, this design achieved a gain of up to 16 dBi with high port isolation (S21 ~ -30 dB), critical for MIMO and polarization-agile systems

In the conclusion, the proposed 2×2 stacked rectangular microstrip patch antenna array demonstrates a promising solution for broadband and circularly polarized applications in modern communication systems. By leveraging the advantages of a stacked patch configuration such as improved impedance bandwidth, enhanced gain, and better axial ratio performance the design effectively addresses the limitations of conventional microstrip antennas. The use of a single-feed arrangement with optimized patch dimensions and stacking layers enables efficient electromagnetic coupling and symmetrical radiation patterns..

III. PROPOSED METHODOLOGY

The proposed methodology includes the design, simulation, and performance evaluation of a 2×2 stacked patch antenna array operating in the C-band frequency range. The design focuses on dual-band operation at 5.2 GHz and 5.8 GHz to meet the demands of modern wireless communication systems. A 2×2 array of stacked microstrip patch elements is employed, where each element consists of two rectangular patches—one lower patch resonating at 5.2 GHz and one upper patch at 5.8 GHz. The patches are separated by a dielectric spacer to enable efficient electromagnetic coupling. The structure is built on an FR4 substrate with a dielectric constant of 4.4 and a suitable thickness to support microwave operation.

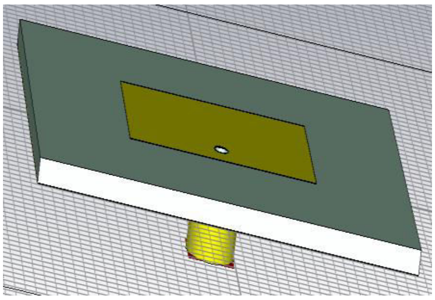

Figure1

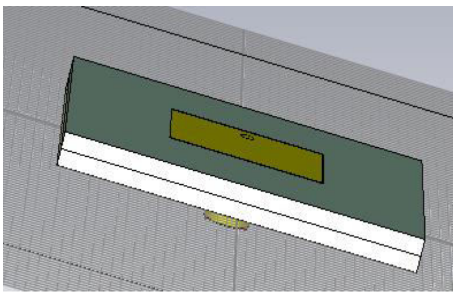

Figure 2

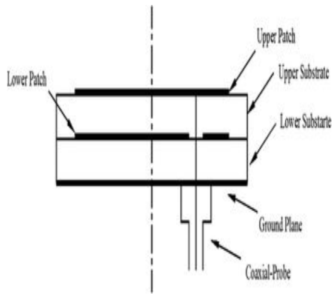

Figure 3

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Figure 1: Single layer microstrip patch antenna , Figure 2: Stacked microstip patch antenna ,Figure 3: Schematic view of stacked patch antenna.

The dimensions of the patches are optimized based on the target frequencies: the lower patch has a length of 13.01 mm and a width of 18.14 mm, while the upper patch has a length of 11.68 mm and a width of 16.27 mm. The antenna is excited using a coaxial probe feed that directly excites the lower patch while the upper patch is excited through electromagnetic coupling. This feeding technique is selected for its low spurious radiation and good impedance matching. CST Studio Suite is used for the electromagnetic simulation of the antenna. Farfield monitors are placed at 5.2 GHz and 5.8 GHz to observe radiation patterns and evaluate performance parameters including return loss, VSWR, gain, directivity, and radiation efficiency. The design parameters and physical dimensions of the antenna are optimized using parametric sweeps in CST to ensure efficient dual-frequency performance.

FLOW CHART:

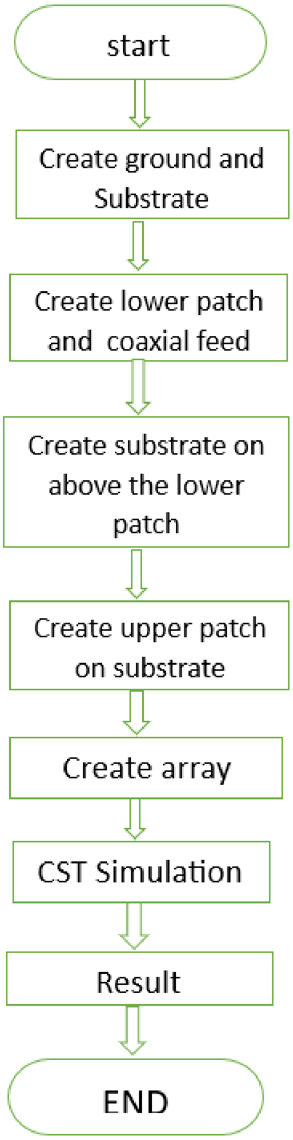

Figure 4: Steps to design Stacked patch microstrip antenna array

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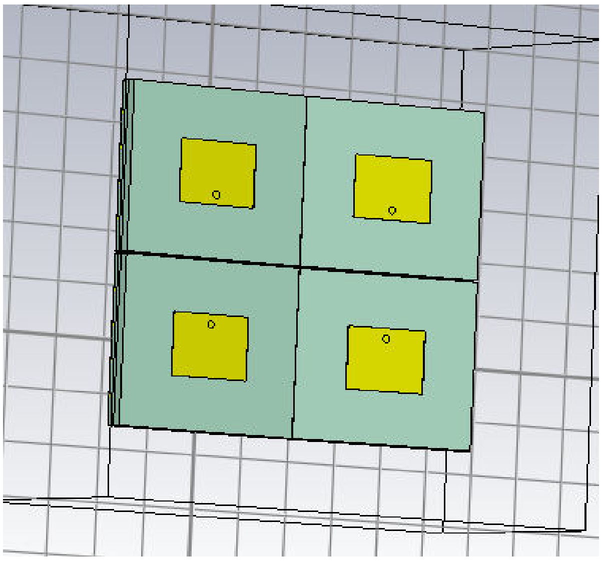

Figure 5:Front side of the 2x2 Stacked array antenna

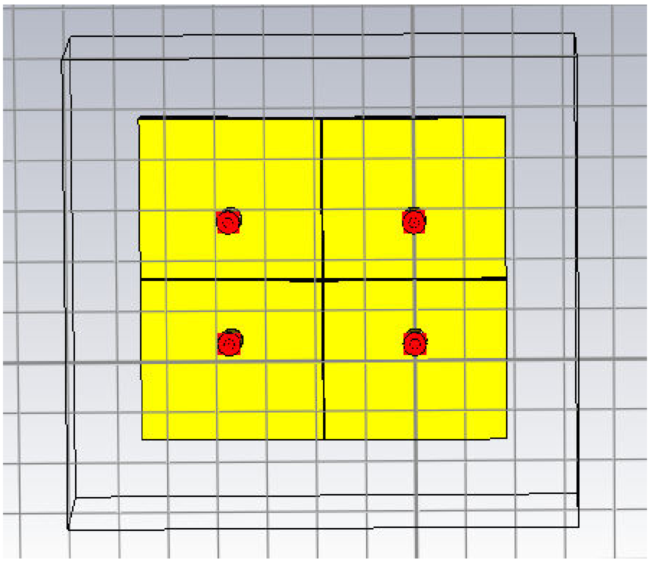

Figure 6: Back side of 2x2 stacked array antenna with coaxial probe feeding technique

Table -1: Antenna Basic Size Parameters

Parameter List

Name	Expression	Value	Description	Type
Wg	= 36.74	36.74	width of ground	Undefined
Lg	= 31.61	31.61	length og ground	Undefined
w	= 18.14	18.14	width of lower patch	Undefined
W1	= 16.27	16.27	width of upper patch	Undefined
L	= 13.01	13.01	lenght of lower patch	Undefined
L1	= 11.68	11.68	length of upper patch	Undefined
OuterDiameter	= 2.34	2.34		Undefined
sbh	= 1.6	1.6	hight of dielectric	Undefined

Parameter List | Result Navigator

S-Parameters:

Scattering parameter or S-parameter (the element of a scattering matrix or S-matrix) describe the electrical behaviour of linear electrical networks when undergoing various steady state simulate by electrical signal. Scattering refers to the way travelling currents or voltage are affected when they meet a discontinuity in a transmission line.

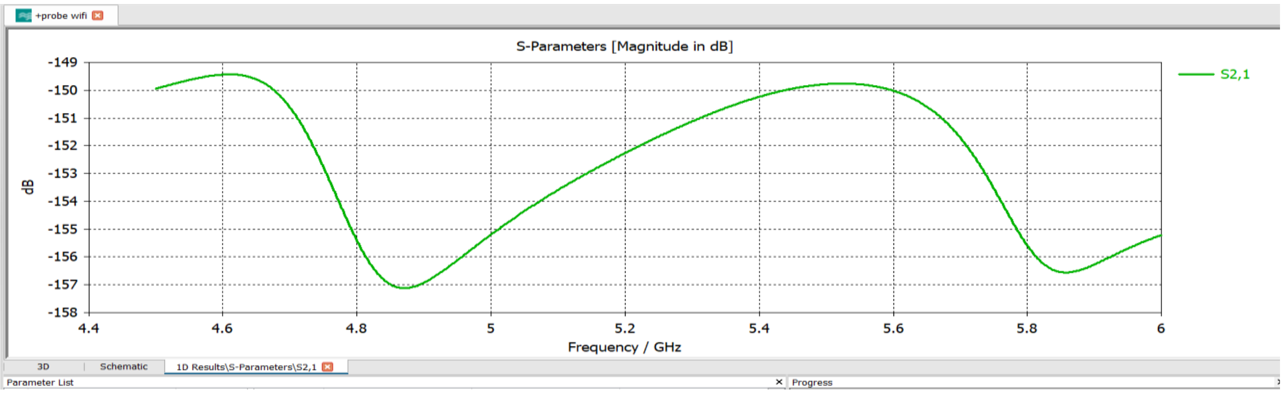

Figure 7: S-Parameters

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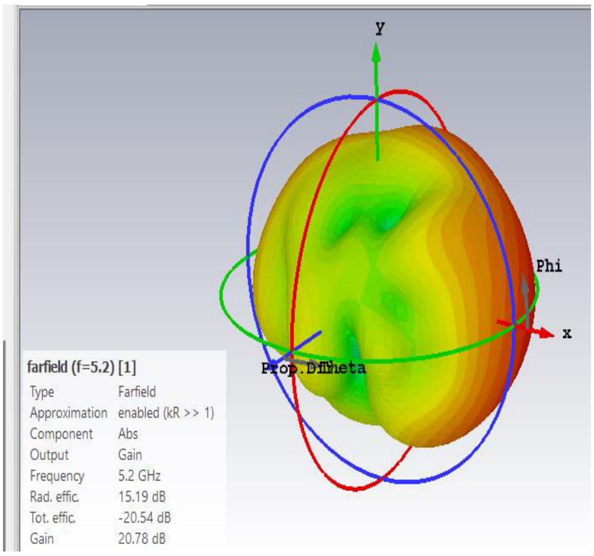
Far Fields:



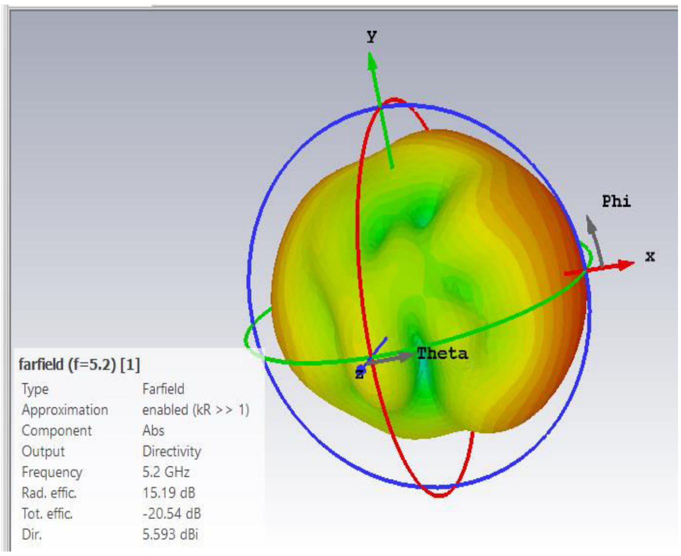
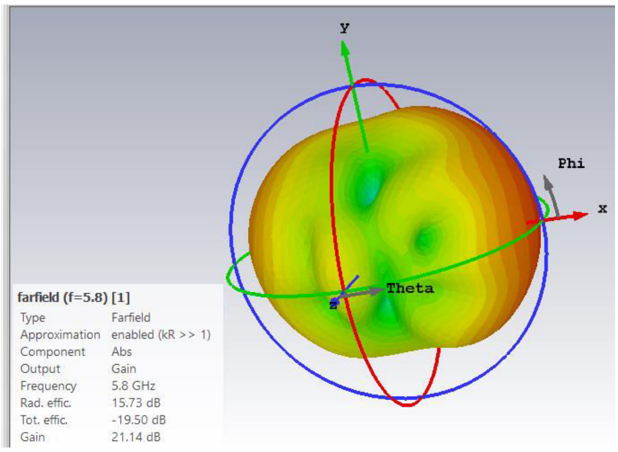


Figure 8: Gain at 5.2GHz

Figure 9: Directivity at 5.2 GHz



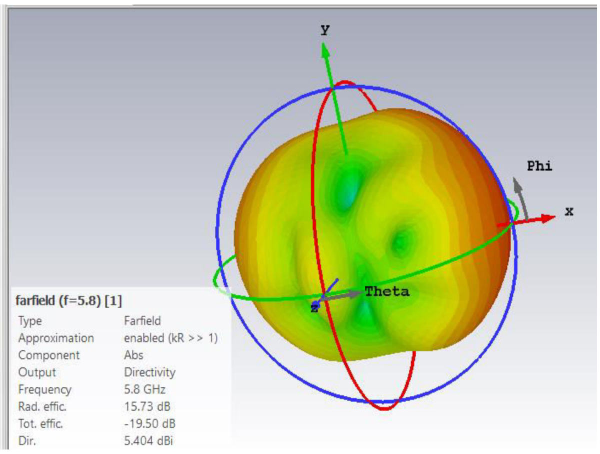
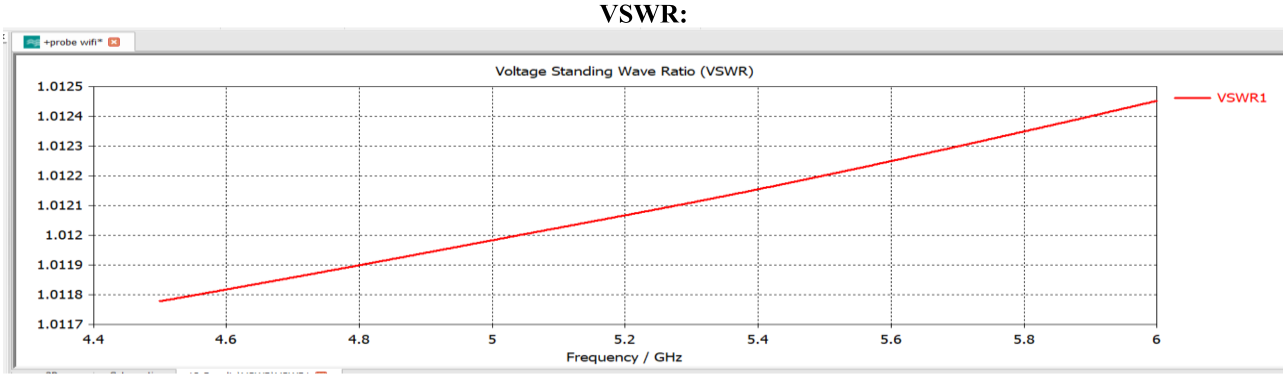


Figure 10: Gain at 5.8 GHz

Figure 11: Directivity at 5.8 GHz

VSWR:



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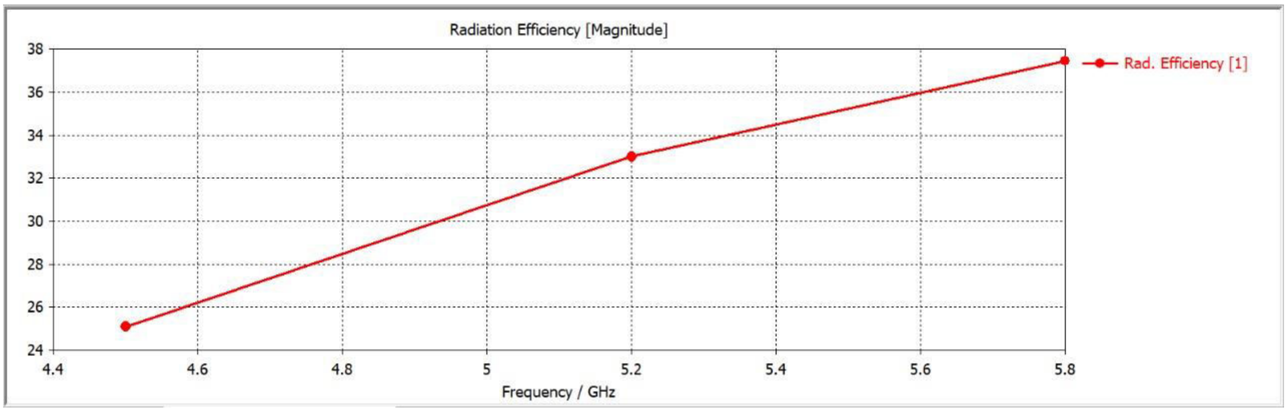
VSWR (Voltage Standing Wave Ratio) is a critical parameter used to evaluate the impedance matching between an antenna and its feed line. A well-matched antenna ensures that most of the power from the source is radiated, with minimal reflection. VSWR is defined as the ratio of the maximum to the minimum voltage along the transmission line and is directly related to the reflection coefficient. In this study, the designed stacked patch antenna exhibits a VSWR close to 1.01 at both 5.2 GHz and 5.8 GHz, signifying excellent impedance matching and efficient power transfer. This high degree of matching is a result of precise optimization of the patch dimensions, feed position, and the stacked configuration, thereby enhancing the antenna's overall performance.

Radiation Efficiency:



Results:

Parameters	**5.2GHz**	**5.8GHz**
Gain	**20.78 dB**	**21.14 dB**
Directivity	**5.593 dBi**	**5.404 dBi**
Return loss	**-152 Db**	**-156 dB**
VSWR	**1.012**	**1.012**
Radiation Efficiency	**33 dB**	**38 dB**

The simulation results show that the proposed stacked patch antenna array exhibits excellent performance in terms of radiation efficiency, impedance matching, gain, and directivity. The radiation efficiency increases from approximately 25% to 38% across the simulated frequency band, indicating efficient power radiation. The Voltage Standing Wave Ratio (VSWR) remains close to 1.01 across both operating frequencies, which confirms excellent impedance matching and minimal reflection. The antenna achieves a gain of 20.78 dB at 5.2 GHz and 21.14 dB at 5.8 GHz, demonstrating strong signal strength in the desired directions. The directivity is measured at 5.593 dBi for 5.2 GHz and 5.404 dBi for 5.8 GHz, reflecting focused radiation patterns. Furthermore, 3D farfield plots reveal multi-lobe radiation characteristics with peak gain directed along the boresight, ensuring directional performance suitable for targeted wireless applications.

IV. CONCLUSION

The design and simulation of a 2×2 stacked patch microstrip antenna array for dual-frequency C-band operation have been successfully carried out using CST Studio Suite. The antenna demonstrates excellent performance with high gain, low VSWR, good radiation efficiency, and effective impedance matching at both 5.2 GHz and 5.8 GHz. The coaxial feed technique ensures compactness and minimal spurious radiation, while the stacked configuration significantly enhances bandwidth and multi-frequency capability. This makes the antenna highly suitable for modern wireless applications such as Wi-Fi and Fixed Wireless Access (FWA) systems. Future work can focus on the fabrication and real-time testing of the prototype to validate the simulated results and potentially explore improvements through material and geometry optimization. The proposed design offers a practical and efficient solution for high-performance, compact wireless antenna systems.

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