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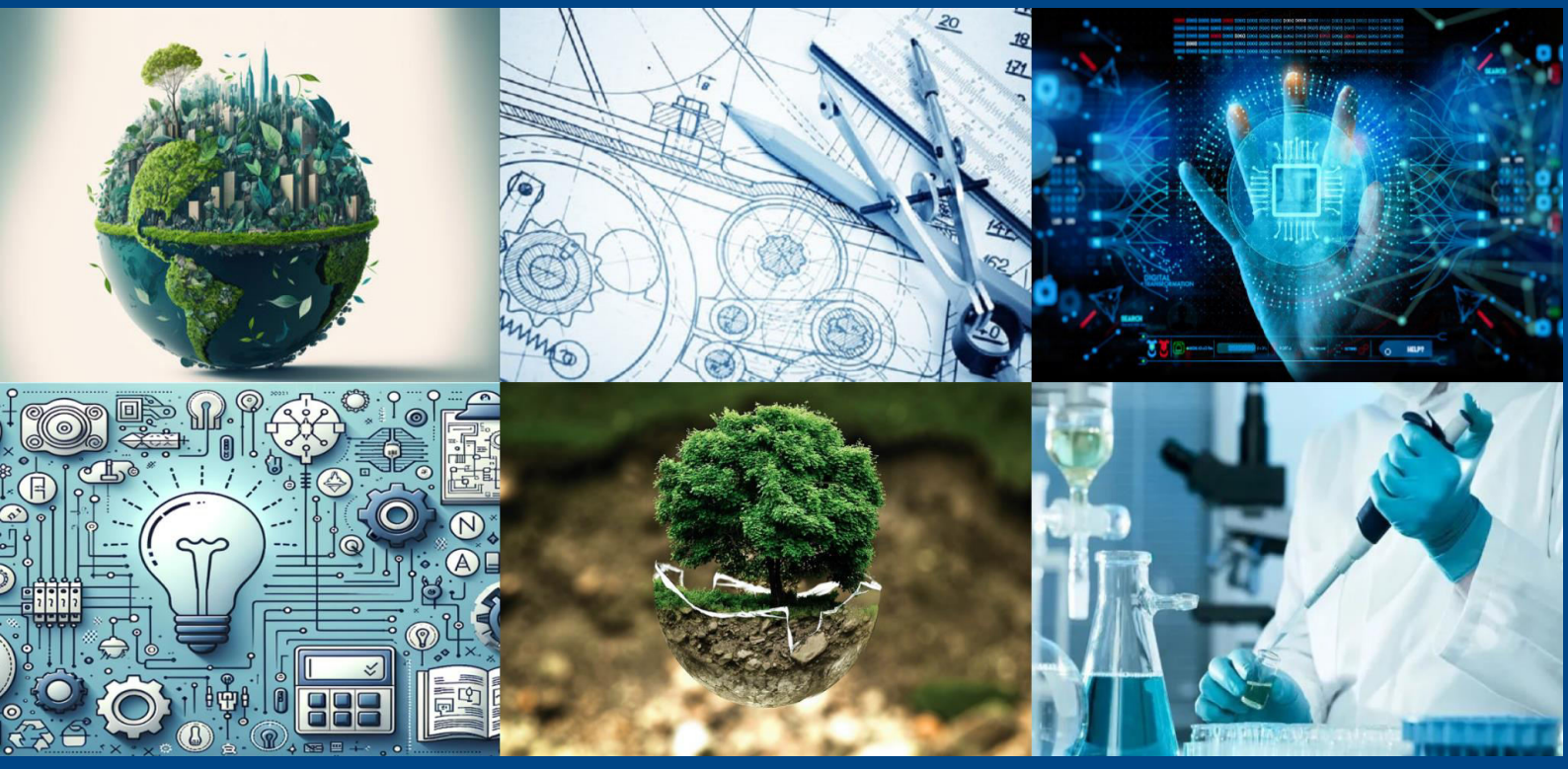

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Design and Analysis of Dual Band MIMO Antenna for 5G Smartphone Application

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ABSTRACT: The need for sophisticated Multiple-Input Multiple-Output (MIMO) antenna systems is rising due to the quick spread of wireless communication technologies like 5G. MIMO technology offers higher spectral efficiency and faster data speeds. The potential for higher data speeds and greater spectrum efficiency lies at the heart of MIMO technology. In order to improve isolation for 5G networks, this project involves the design and analysis of dual-band MIMO antenna system. This project aims to design and analyse a dual-band MIMO antenna optimized for 5G smartphone applications. This will ensure improved performance for 5G applications at (3.4-3.7GHz) and (4.87-5.07GHz) by improving isolation. It is necessary to examine and make sure that the MIMO diversity parameters such as the Envelope Correlation Coefficient (ECC), Diversity Gain (DG) are in excellent agreement with the ideal values.

KEYWORDS: MIMO antenna, smartphone, 5G, ECC, DG

I. INTRODUCTION

MIMO technology offers higher spectral efficiency and faster data speeds, making it crucial for improving wireless communication performance. This project focuses on designing and studying an eight-element MIMO antenna system with the aim of providing a compact solution to enhance isolation for 5G networks.

The proposed antenna aims to address the challenges of designing small, high-isolation antenna elements within constrained spaces. Key MIMO diversity parameters such as Envelope Correlation Coefficient (ECC) and Diversity Gain (DG) will be analysed to ensure alignment with ideal values. MIMO antenna signal correlation should be low with good impedance characteristics and individual elements possess good efficiency and isolation.

5G has significantly enhance mobile connectivity, driving the expansion and development of networks. Any mobile application and service will have the ability to connect seamlessly with anything, anytime ranging from individuals and communities to physical devices, workflows, digital content, essential knowledge, real-time data, and various goods in entirely flexible, reliable and secure ways.

Smartphones are gaining more popularity nowadays, due to their wide variety of functions such as communication services, mobile financial services and entertainment. Multiple-Input-Multiple-Output (MIMO) operation can effectively increase the spectrum efficiency or channel capacity, so applying MIMO technology in smartphone will ensure the enhancement of its channel capacity.

The proposed antenna operates as a dual band antenna with eight elements which are distributed along two side edges of the smartphone, meet the requirements of full screen smartphone antenna design.

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II. ANTENNA DESIGN

The structure and dimensions of the proposed antenna array is shown in Figure 1. As is seen, the antenna system consists of eight antenna elements. The single antenna is designed and can be operated in the bands of 3.4-3.7GHz and 4.87-5.07GHz. The antennas are printed on the inner and outer surfaces of the side frame of the smartphone system circuit board. In order to meet the trend of modern ultra-thin smartphones, the height of the edge frame of the mobile phone is 5mm. All the eight antenna elements have same structure and dimensions.

The area of each antenna on the side frames is 3.9mm x 17mm. The system circuit board is selected to have a size of 130mm x 74mm. Both side-edge frame and the system circuit board are fabricated using 0.8mm-thick FR4 substrate of relative permittivity 4.4 and loss tangent 0.02.

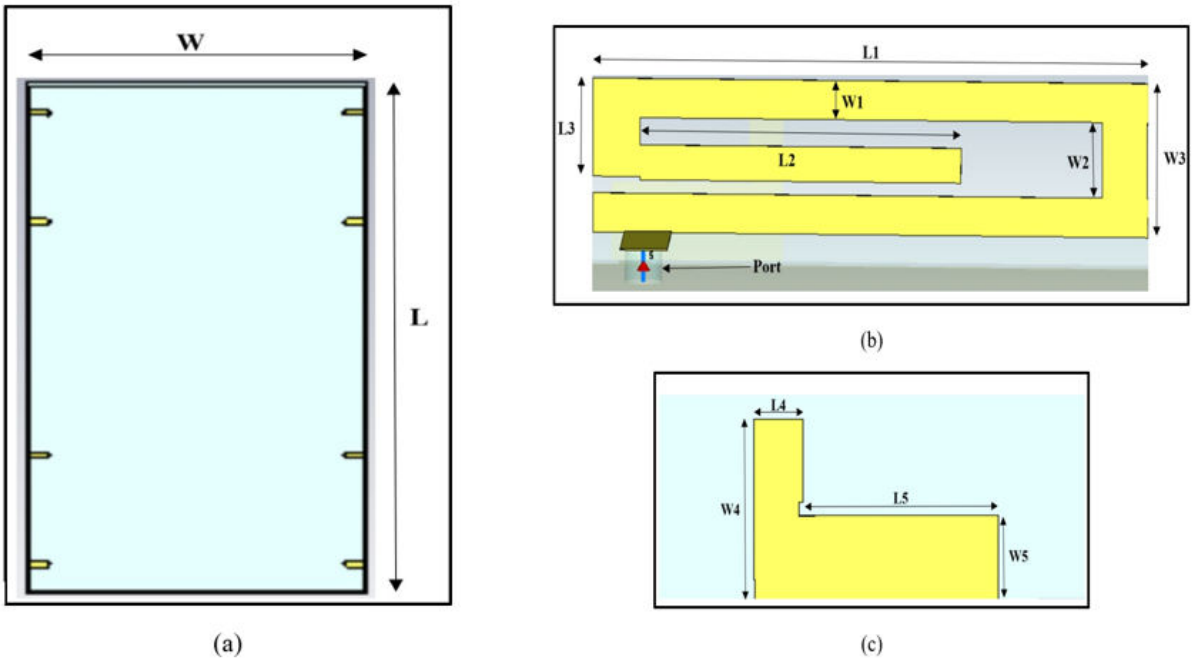

Figure 1: (a)Proposed 8-port antenna array structure (b) Bending line monopole (Radiating Element of MIMO antenna) (c) L-shaped short-circuit stub

The radiation part of the antenna can be divided into two parts: front radiation part is a bending line monopole, feed part as shown in Fig.1 below; the back of the radiation part is a L-shaped short circuit stub.

Parameter	L	W	L1	L2	L3	L4
Dimension (in mm)	130	74	17.7	10	2.5	1
Parameter	L5	W1	W2	W3	W4	W5
Dimension (in mm)	4.4	1	1.9	3.9	4.2	2

Table 1: Parameter of the antenna proposed

III. RESULTS AND DISCUSSION

The Simulated results were performed by using CST Microwave Studio 2024. Figure 2. Shows the simulated S parameters for the proposed antenna array. Figure. 2. Shows that the Reflection Coefficient (S11, S22, S33, S44, S55, S66, S77. S88) is less than -6dB. Figure 3. Shows the transmission coefficient (S21, S31, S41, S51, S61, S71, S81) is

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less than -10dB and less than –14dB at 3.4GHz, which is acceptable for smartphone applications. Figure 4. Shows the VSWR of the proposed MIMO antenna indicating that acceptable impedance matching is obtained i.e... VSWR is less than 3 and shows VSWR is in the desired frequency range of (3.4-3.7GHz) and (4.87-5.07GHz). Fig.5 The total efficiency of 8-port MIMO antenna at (3.4-3.7GHz) is around 65% for (1,2,3,4) antennas and around 50% for (5,6,7,8) antennas, efficiency is around 30% at (4.87-5.07GHz) for all the antennas.

Because of the antenna position placed at ground plane, the results show the reflection coefficient of four antennas (1,2,3,4) placed on the edges of the ground plane is same and the reflection coefficient of other four antennas (5,6,7,8) which are placed on the middle of the ground plane is same.

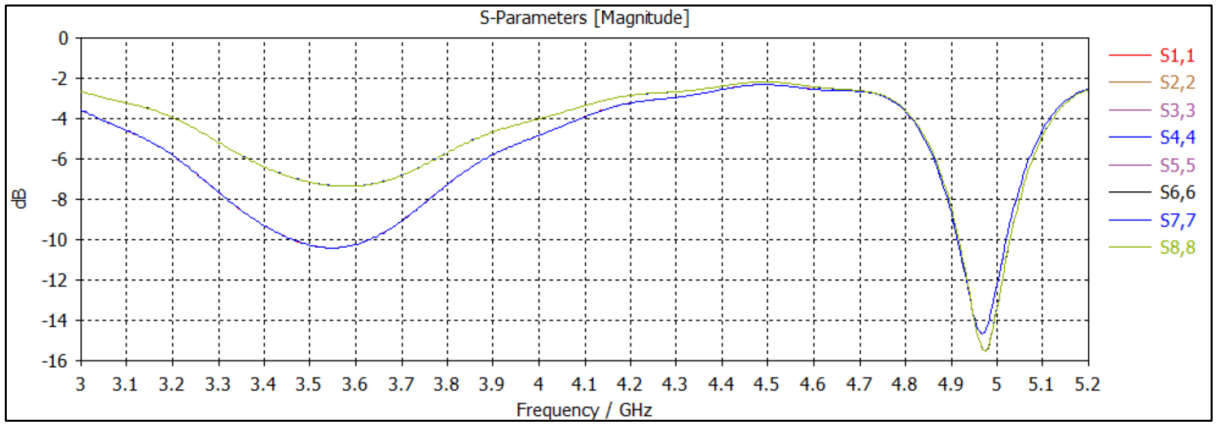

Figure 2: Reflection coefficient of 8-port Dual Band MIMO antenna

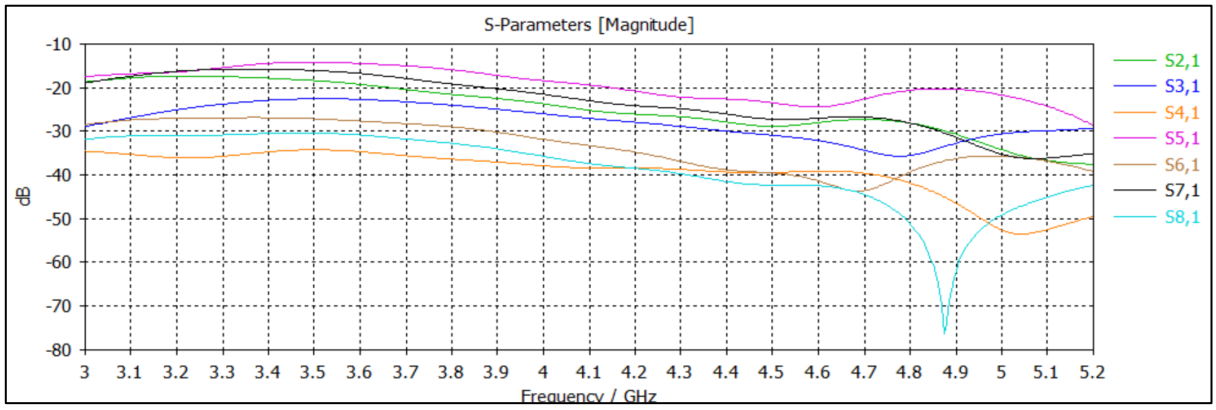

Figure 3: Transmission Coefficient of 8-port Dual Band MIMO antenna

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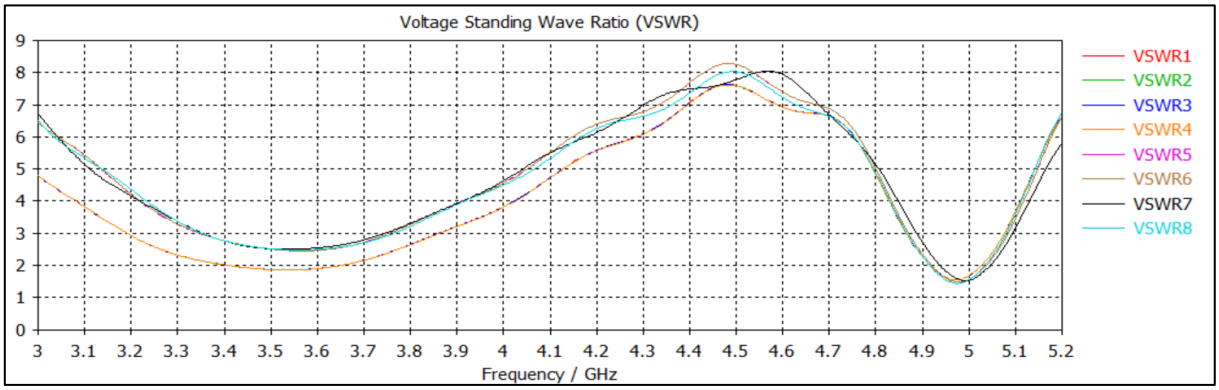

Figure 4: VSWR of 8-port Dual Band MIMO antenna

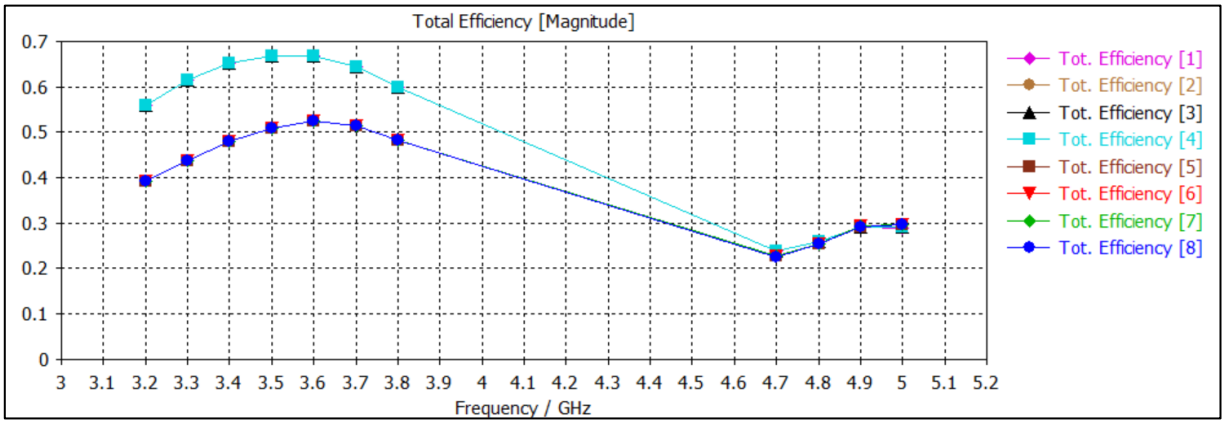

Figure 5: Efficiency of 8-port Dual Band MIMO antenna

IV. MIMO ANTENNA PARAMETERS

Evaluation of MIMO antenna performance involves assessing various parameters such as ECC (Envelope Correlation Coefficient), DG (Diversity Gain). A lower correlation coefficient indicates better support for higher data rates. For practical purposes, an acceptable ECC value is typically less than 0.1. The ECC of the proposed antenna is calculated using the equation below as referenced in [6].

$$ECC_{(i,j,\ldots,N)} = \frac{\left|\sum_{n=1}^{N} S_{i,n}^{*} S_{n,j}\right|^{2}}{\prod_{k=i,j}\left[1-\sum_{n=1}^{N} S_{k,n}^{*} S_{n,k}\right]}$$

where i and j are antennas 1 and 2, and N is the number of antennas. Figure 6 displays the ECC graph for the proposed MIMO antenna, indicating ECC values below 0.1 across all operating frequencies. The formula for calculating directivity gain (DG) using ECC is represented below. Figure 7 illustrates the diversity gain of the proposed MIMO antenna for operating frequencies, exhibiting a favourable value of around 10 dB.

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$$DG = 10 \times \sqrt{1 - |ECC|}$$

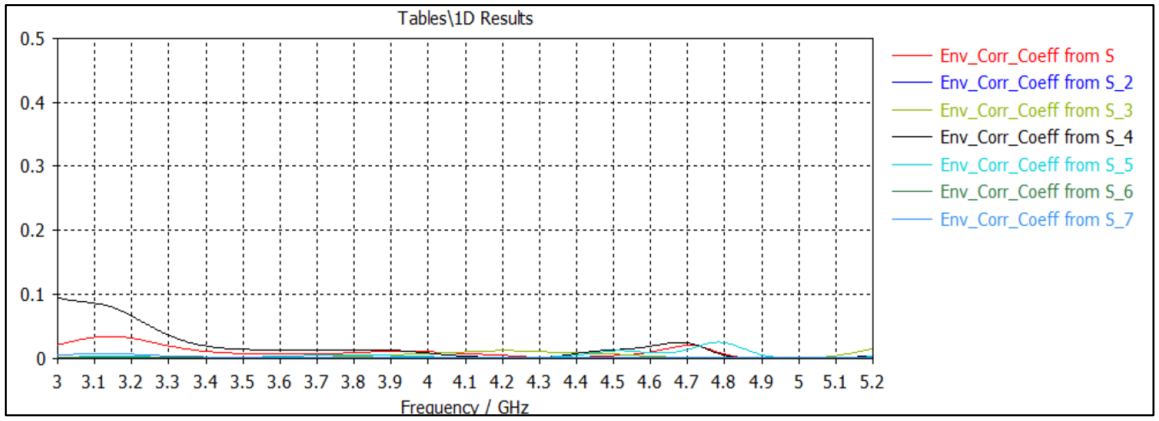

Figure 6: Envelope correlation coefficient of 8-port Dual Band MIMO antenna

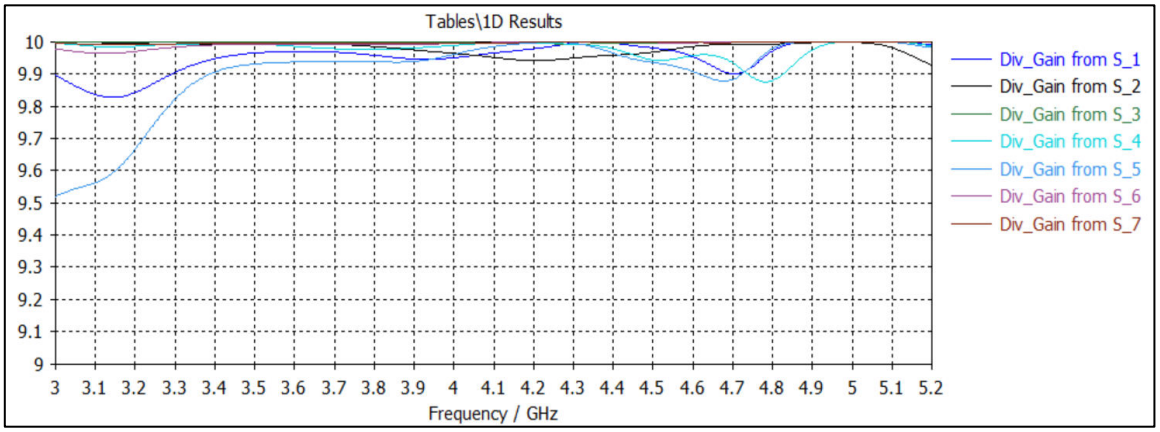

Figure 7: Directive Gain of 8-port Dual Band MIMO antenna

V. CONCLUSION

This paper introduces a dual-band eight-antenna MIMO array for 5G smartphone application, with enhanced isolation. The antenna operates across two frequency bands, 3.4-3.7GHz and 4.87-5.07GHz. The antenna supports a return loss less than -6dB and an isolation of better than 14dB for both frequency bands. The paper investigates the diversity performance of the MIMO antenna, demonstrating measured ECC values below 0.1 and a DG of around 10 dB across operating frequencies. Consequently, the proposed MIMO antenna offers a promising solution for 5G applications.

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