DESIGN OF A NOVEL U-SHAPED MIMO ANTENNA FOR 5G APPLICATIONS

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ABSTRACT

MIMO (multiple input-multiple output) is an antenna technology for wireless communication in which multiple antennas are used at both the source and destination. By boosting the capacity of radio frequency systems MIMO creates a more stable connection and less congestion. Microstrip Antenna is a low profile directional radial antenna. These are simple and inexpensive. They can be used in various applications including aircraft, spacecraft, satellite, missile, mobile, radio and wireless communication. Nowadays in telecommunications 5G is the fifth-generation technology standard for broadband cellular network. The main advantage of this network is that greater bandwidth giving higher download speed eventually up to 10 gigabyte per second. The most important device to support 5G communication is Microstrip Antenna which meets certain requirements like Physical size, low profile and easily fabricated. In this project a Novel U-Shaped MIMO antenna is proposed that can be used for dual-band applications. The proposed antenna must have small size, better Reflection coefficient, VSWR, Gain, Bandwidth, Return loss, and Directivity etc.

Keyword: - Key *word1:MIMO , Key word2:Microstrip Antenna, Key word3:U-shaped MIMO Antenna, Keyword4 :5G Communications.*

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1. INTRODUCTION

The popularity of mobile communications systems has drastically increased during the last decade and the market demand continues to increase. The antenna one of the most important design issues in modern communication units as a fundamental part of these systems. Therefore, the design has to evolve to meet the new requirements. In the modern era of wireless communication, of the factors like cost and efficiency of the high-speed data network system plays a very important role to fulfill the demand. Nowadays MIMO system is become very popular because of its high data rate, good communication channel capacity greater network energy efficiency and spectral efficiency that

is 100 times higher than Long-Term Evolution (LTE).Over the same frequency in MIMO channel, it transmits multiple data without increasing its bandwidth. Multiple antennas are employed on both the transmitter and receiver sides of the MIMO systems that improve the overall performance of wireless systems by effectively exploiting the multipath fading. To include a number of MIMO antenna elements, the capabilities of MIMO system should increase linearly. The close positioning of antenna elements in antenna devices results in high mutual coupling due to which the overall performance of MIMO gets degrade. The acceptable range of inter element isolation is above 10 dB in MIMO antenna system but if it is more, it will be better. In earlier days, to improve the isolation, several approaches have been used like neutralization line introduction of the protruded ground plane etched slots and self-isolation etc. Besides the above-mentioned approaches, some of the new approaches adopted to use in 5G mobile devices like orthogonal polarization and pattern diversity techniques, modified ground structure, Metamaterial structures for MIMO antenna array. The Micro strip antennas are increasing in demand for use in communication systems due to their compact size, light weight and cost effectiveness. Currently this antenna is commercially used for mobile communication and satellite communication and many other wireless applications. However, in future prospective the Internet of things will play a big role in our daily and social life. A large number of devices will be connected through wirelessly. Apart from performance cost and compactness play a vital role in commercial applications.

The motivation of this work to design a low cost four-element MIMO Antenna is to fulfill the future communication demand for 5G Application band (3.5GHz), A reverse U shape slot is cut inside the patch to make the structure more compact. In the next phase of design, MIMO Antenna for single, two and four-element antenna are analyzed. So, based on the design and application requirement the antenna can used and apply in the different devices. The isolation needs to improve in the case of increase in the element of antenna.

A dumb-bell shaped isolator is used to improve the isolation performance and diversity performance. To understand the performance of the MIMO antenna a detailed analysis is to be carried out. The antenna is designed and analyzed using CST, and the simulation result is also validated through measurement.

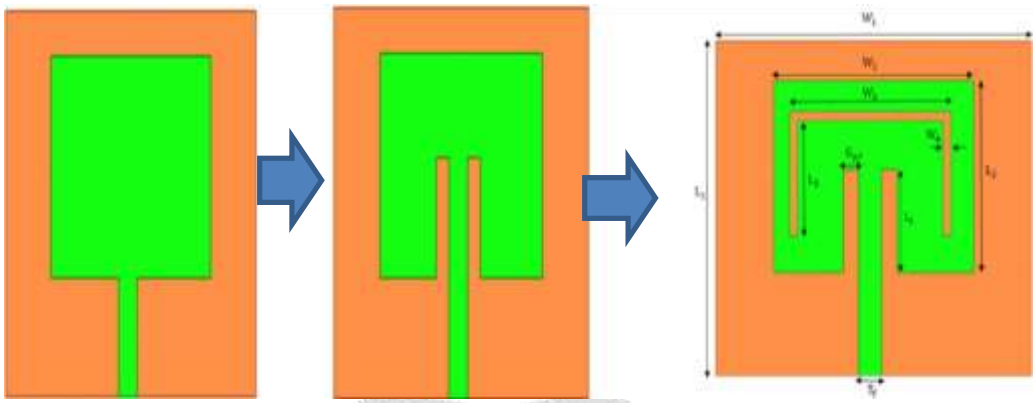
2. DESIGN AND ANALYSIS OF PROPOSED ANTENNA

2.1 Single element MIMO Antenna:

The detailed analysis of the antenna is carried out by using CST software. The Antenna is designed on the low cost Flame Retardant 4(FR-4) substrate sandwiched between copper patch and ground plane.FR-4 offers good flexibility, low cost and is readily available. Here we designed a single element antenna resonating at 3.5GHz frequency. The detail analysis of the antenna is carried out by using CST (Computer Simulation Technology) software.

The design parameters of the antennas are W1=41 mm, L1=34.836 mm, W2=26.08 mm, L2=20 mm, W3=20 mm, L3=13 mm, Tf=3 mm Li=10.72 mm, W4=1 mm, and Gpf =2 mm.

A basic antenna with full ground structure is designed and analyzed initially and a slot is placed inside the patch. The reverse U-shaped slot in the patch provides a good impedance bandwidth performance. It is perceived that, the proposed antenna covers the frequency spectrum from 3.45 GHz to 3.55 GHz, with a good return loss of -25.86 dB at 3.5 GHz. The antenna shows good gain that is 4.14 dB at 3.5 GHz. Fabricated prototype images and measurement setup is shown below.



Antenna 1 Antenna 2 Proposed Single antenna

Figure- 1 DESIGN GEOMETRY FOR SINGLE ELEMENT ANTENNA

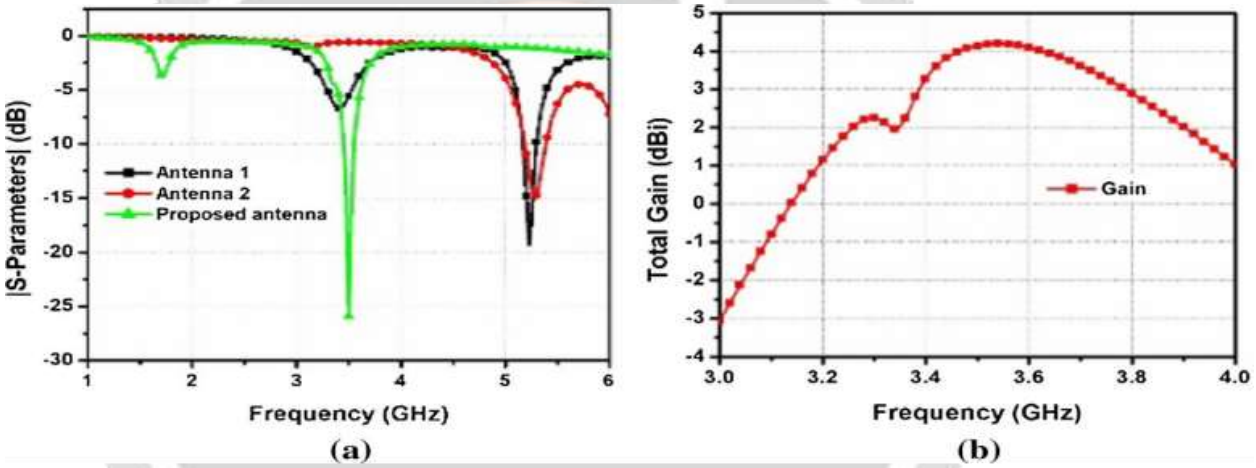


Figure- 2 a SIMULATED S-PARAMETERS **2 b** GAIN OF SINGLE ELEMENT ANTENNA

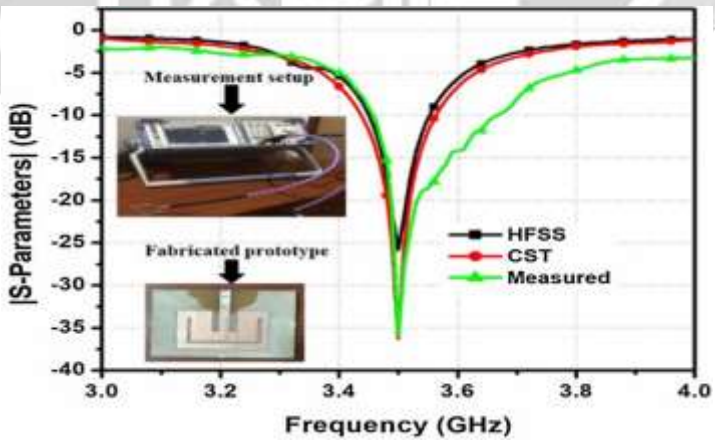


Figure- 3 COMPARISONS OF THE SIMULATED AND S11 OF SINGLE ELEMENT ANTENNA

2.2. Two element MIMO Antenna:

The MIMO antenna 1, is shown in Fig. 4a. is operating with the desired 3.5 GHz frequency, but the antenna is poorly isolated due to an electromagnetic coupling between the antenna's elements. To enrich the isolation performance of the MIMO antenna1, a dumb bell-form isolator is used between them. The electromagnetic coupling between them to -21.5 dB by the usage of isolator. The Comparison of simulated return loss of MIMO Antenna 1 and MIMO Antenna 2 with CST simulator is shown in Fig. 5a. Isolation is improved by the proposed two element antenna in the desired frequency spectra. MIMO Antennas design parameters are W4=75.59 mm, L4=34.836 mm, W5=8.57 mm, L5=30.836 mm, L6=3.61 mm, L7=4.57 mm, W6=6.57 mm, W7=0.5 mm and radius (R) of the circle is 2 mm.

It has been found that the isolation structure has more advantage than without isolation, since the cross-polar component value has been reduced due to the isolating element.

The analysis of diversity parameter like ECC (envelope correlation coefficient) and diversity gain (DG) are necessary to examine the performance of the MIMO antenna. The ECC for the MIMO antenna can be analyzed by S-parameter approach (CST software).

$$\rho_e = \frac{\left|S_{ii}^{*}S_{ij} + S_{ji}^{*}S_{jj}\right|^2}{\left(1-\left(\left|S_{ii}\right|^2+\left|S_{ji}\right|^2\right)\right)\left(1-\left(\left|S_{jj}\right|^2+\left|S_{ij}\right|^2\right)\right)}$$

The MIMO Antenna DG can be determined as below,

$$DG = 10^{10}\sqrt{1-(\rho_e)^2}$$

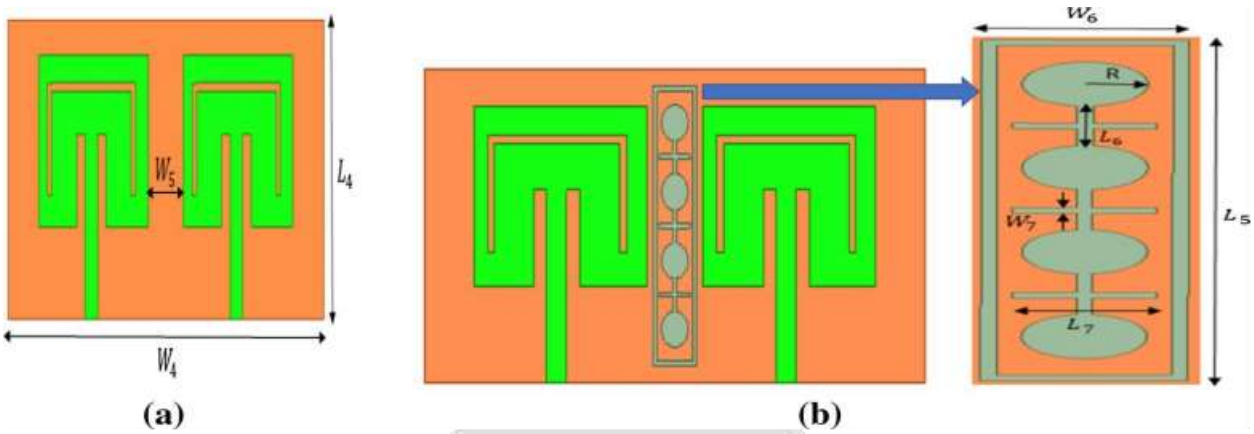


Figure- 4 MULTILATERAL STRUCTURE OF THE **a** MIMO ANTENNA 1 AND **b** MIMO ANTENNA 2

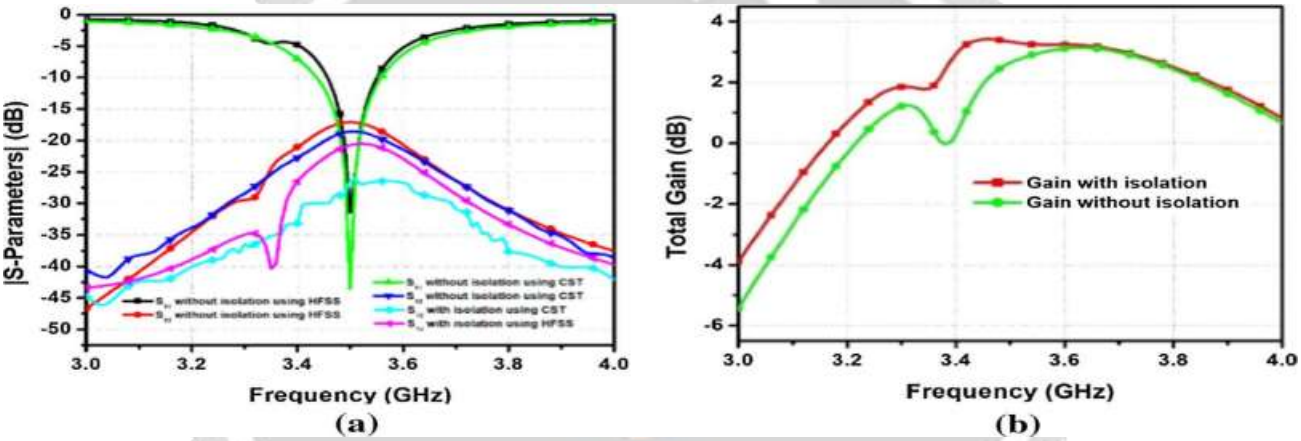


Figure- 5 a SIMULATED S-PARAMETER COMPARISON, **b** GAIN OF MIMO ANTENNA 1(WITH NO ISOLATION ELEMENT) and MIMO ANTENNA 2 (WITH ISOLATION ELEMENT).

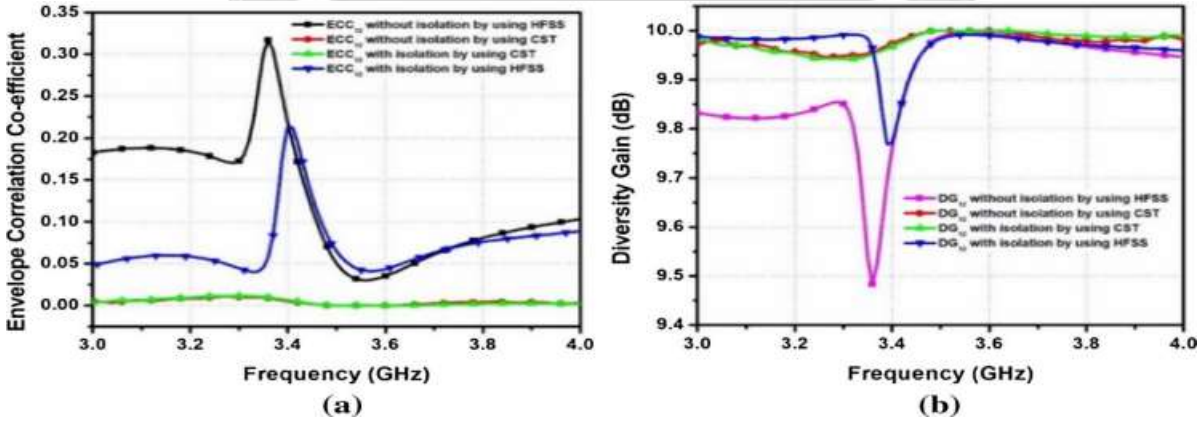


Figure- 6 EXECUTION ANALYSIS OF **a** ECC **b** DG BY USING CST FOR 2- ELEMENTS MIMO ANTENNA

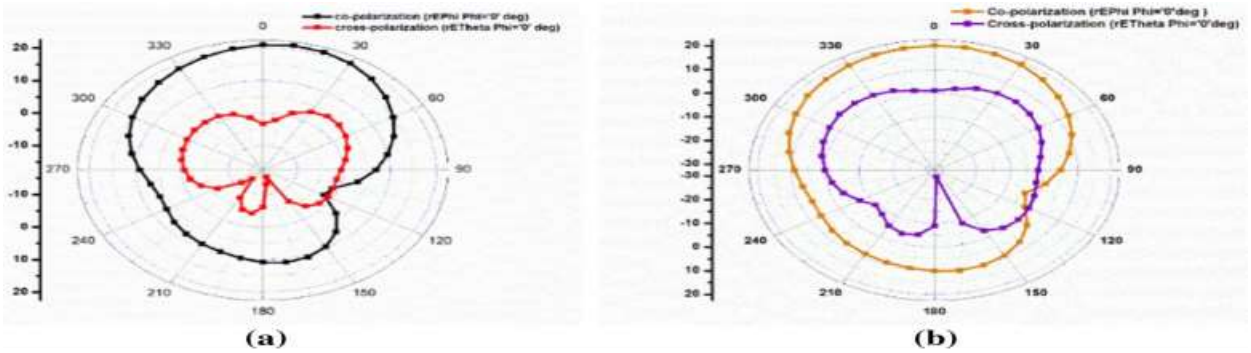


Figure- 7 SIMULATED RADIATION PATTERN OF E-PLANE AT 3.5GHz

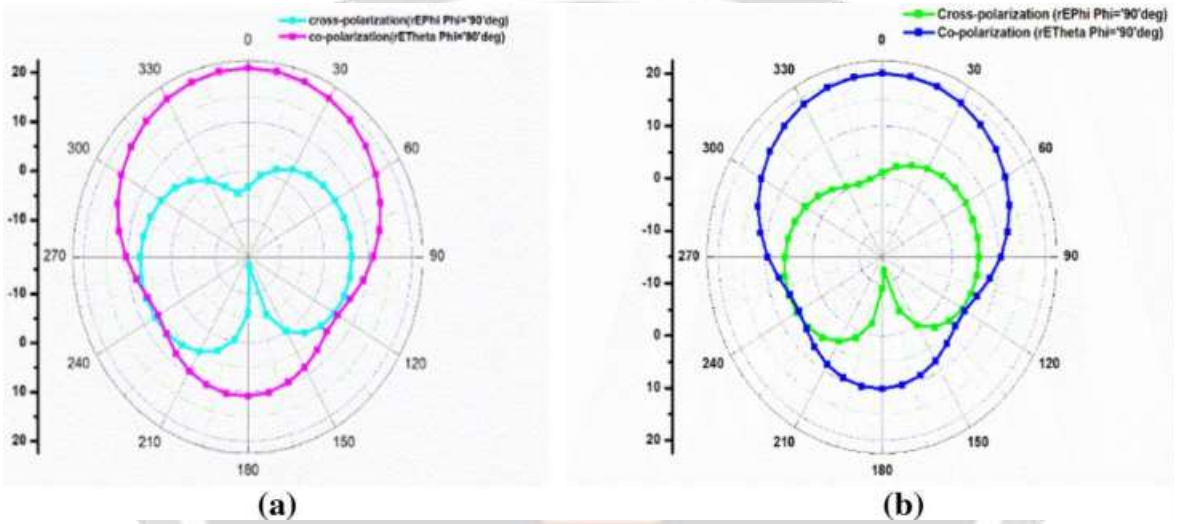


Fig. 8 Simulated radiation pattern of H-Plane at 3.5 GHz

In S parameter approach, the ECC and D.G. is also in satisfactory ranges in the desired frequency i. e. 3.5 GHz. The simulated radiation pattern of E and H planes for the MIMO two-element antenna with and without isolation is illustrated below. Directional radiation pattern and co-polarization, strongly compared with the cross-polarization for both fields is almost achieved by the MIMO antenna with two-element. In reducing mutual coupling between the antenna elements, isolator has played an important role.

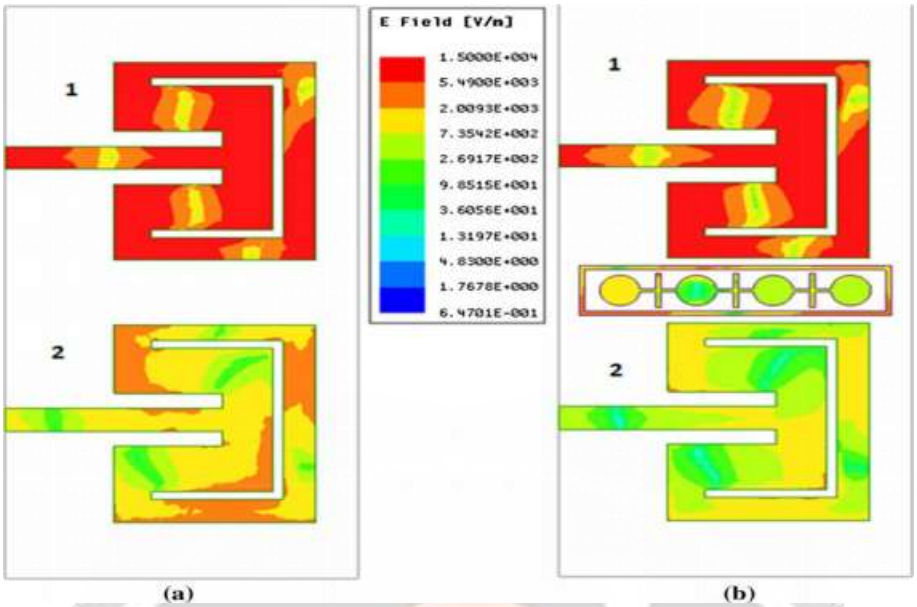


Fig. 9 E-FIELD DISTRIBUTION WITH AND WITHOUT ISOLATION ANTENNA

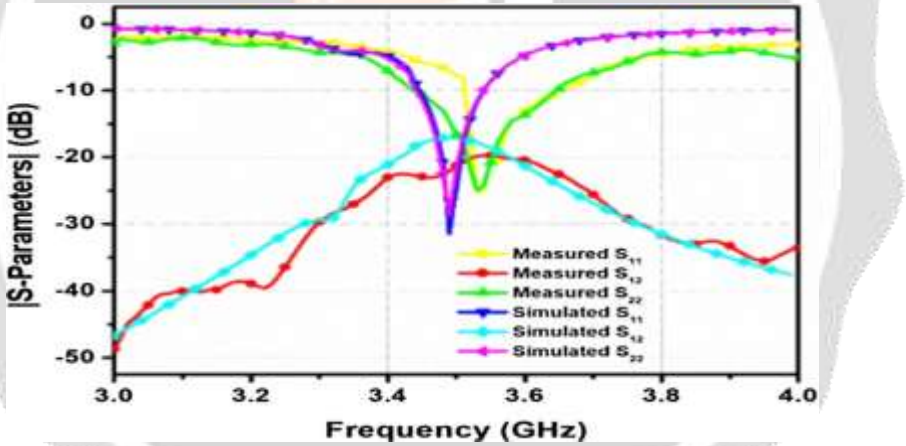


Figure- 10 COMPARISON OF MEASURED AND SIMULATED S-PARAMETERS

2.3. Four element MIMO antenna:

The MIMO antenna system with four-elements is shown in fig11. a and b as given below except (MIMO Antenna 3) and along (MIMO Antenna 4) isolator sequentially. A dumb bell shape parasitic element placed between port 1 and 2 and port 3 and port 4 to improve the performance of MIMO antenna. The simulated scattering parameters is shown in Fig.12. It shows that the antenna covered desired frequency spectrum.

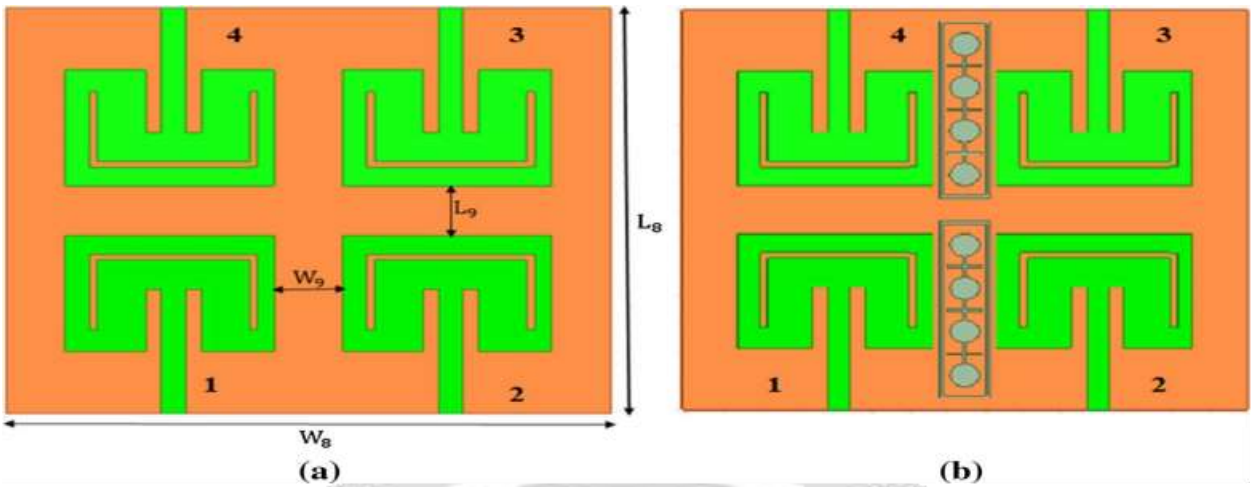


Figure- 11 GEOMETRY STRUCTURE OF **a** (MIMO ANTENNA 3) **b** ALONG ISOLATION (MIMO ANTENNA 4).

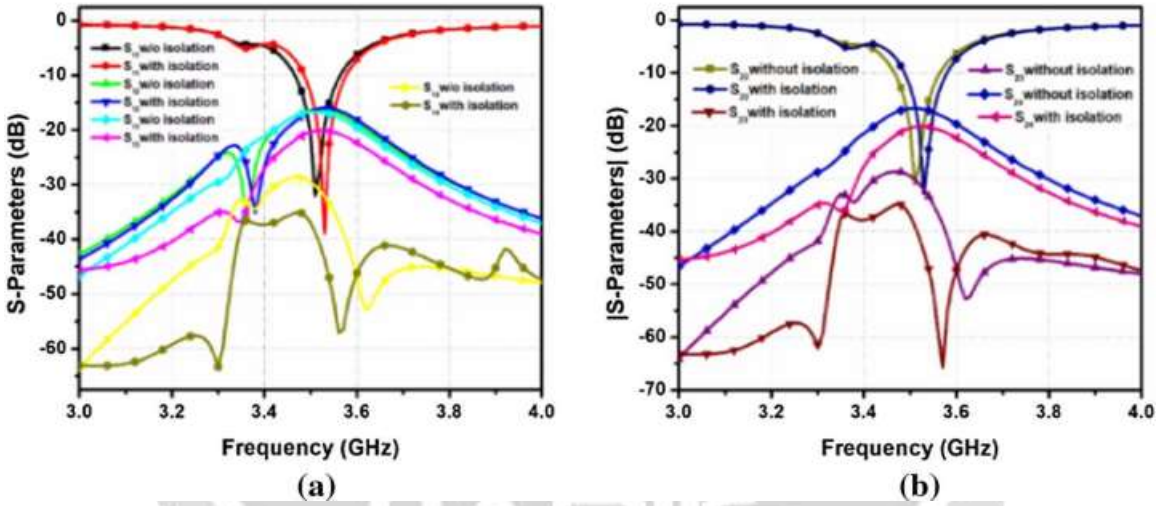


Figure- 12 a and **b** S-PARAMETERS FOR MIMO ANTENNA 3 and MIMO ANTENNA 4.

The antenna is isolated between two adjacent elements by -17 dB (S21 with isolation) and -30 dB between the two-faced antenna elements (S32 with isolation) at 3.5 GHz due to the remarkable distance of each element. In order to assess the overall performance of the MIMO distinction parameter, the ECC and D.G. should be examined in detail.

3. CONCLUSION

In this article, a low profile MIMO antenna for four elements which can be used for 5G applications is reported. To enhance the isolation, a dumbbell-shaped parasitic element is inserted between radiating elements of antenna. The four-element antennas are placed side by side on the FR-4 substrate with maximum dimension of 70×75.5 mm2 and 69×144 mm2 respectively. . The maximum gain of four and element MIMO antenna is achieved at 3.23 dB, 3.21 dB for 3.5 GHz. The diversity parameter of MIMO antenna is also in desirable range as per industry standard. It is clearly shown that the proposed antenna is less complexity with existence of full ground as compared to existing work, The future scope of the proposed antenna is to obtain multiple frequency bands by using metamaterial and FSS (frequency- selective surface) structure incorporate in the design to improve the diversity of the antenna

4. REFERENCES

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