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Compact MIMO antenna design for upcoming 5G applications

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Abstract- *In this article, we designed a low-cost MIMO antenna for 5G based IoT applications. The antenna covers the frequency spectra from 25.8- 29.4 GHz. The gain found near about 5.7 dBi at 28 GHz. The Antenna is design, simulated, and analyzed on ANSYS HFSS. The ECC and DG performance of the four-element MIMO antenna is studied and found that both performances are useful in that range. The different antenna structures analyzed in MIMO Antenna. The maximum antenna dimension found near about 9.48×7.36 mm^2.*

Keywords- *IoT, Compact, MIMO, 5G*

I. INTRODUCTION

Today the world is running towards technology, and each one carrying at least two antennas with them. Every ten years, a new generation is coming into mobile communication. Present 4G technology does not have better channel capacity, so research is going on 5G to improve capacity, latency, and mobility. From generation to generation, frequency is going to increase, which results in the reduction in the antenna size due to this system, complexity increases. Some recommended bands for 5G are 27.5-29.5GHz, 33.4-36GHz 37-40.5 GHz, 42-45 GHz, 47-50.2 GHz, 50.4-52.6 GHz, and 59.3-71GHz. One of the essential applications of 5G is IoT for connecting the number of devices at a time.

For stable communication and a higher transmission rate, MIMO (multiple inputs multiple outputs) technology is useful. It uses multiple antennas at the transmitting side and various antennas at the receiving side. Because of this, it increases the channel capacity with the same transmitting power. It is known that MIMO operation can highly improve the link reliability, capacity, and data rate of the wireless communication system. And MIMO is going to be used in the 5G devices.

Wireless mobile technology from 0G to 4G brings a revolution in mobile communications [1]. Each generation has some improved qualities [2]. Even though 4G has so many applications, it cannot solve some problems like high energy consumption, crowded channels, inadequate coverage, and low QoS (Quality of Service) [3]. Thereforemobile communication updated to 5G to resolve the disadvantages of 4G and to increase

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the data rate [4]. 5G has so many frequency bands [5], but the Unused or underutilized broadband spectrum exists at 28 GHz. This spectrum has low atmospheric absorption, low path loss, and better propagation conditions [6]. AF Kaeibat all designed a 28 GHz antenna with slots on the patch, that antenna covered 26.81-29.29GHz frequency band with VSWR 1.02 and returned loss -39.3dB [7].

As the number of users increasing day by day traffic of the spectrum increases, and there is a possibility of data corruption. But MIMO increases the channel capacity with the high data rate, low BER, and support multi-users because of added features of diversity and multiplexing [8]. A 28 GHz MIMO antenna designed for UWB applications, and it covers a band of 13GHz, but the gain is only 2.39 dB [9].

This article presents a design and analysis of four elements MIMO Antenna for 5G IoT Application. The design and simulation Antennas done using 3D Electromagnetic ANSYS HFSS [10] software. The antenna works in the frequency range of 25.8 GHz to 29.4 GHz—the antenna designed on the low-cost FR-4 substrate.

II. SINGLE ANTENNA DESIGN

The antenna is designed on the FR-4 substrate with dielectric permittivity (ε_r) =4.4, thickness (h) =1.6 mm, and loss tangent (δ) =0.09. The designed geometry of the antenna shown in Fig.1. The parameters are L1=3.53mm, L2=1.67mm, L3=1.462mm, W1=5.12mm, W2=0.93mm, W3=3.26mm, W4=1.18mm, W5=0.9mm. The overall dimension of the single element antenna is 5.12×3.53 mm^2.

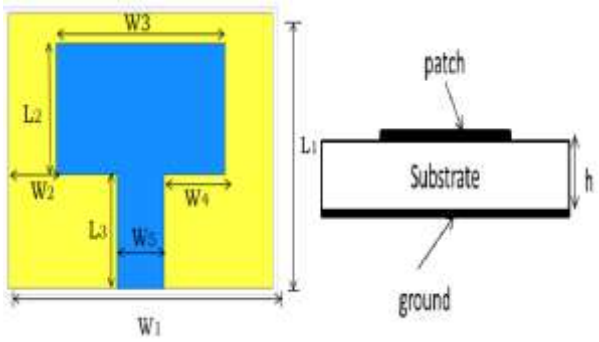

Fig. 1. Design Geometry of Antenna 1

The simulated S11 parameter shown in Fig. 2 (a). The antenna covers the frequency spectra from 26.9 to 29.5 GHz. The antenna has also demonstrated a good gain in the frequency band in that particular band. The maximum gain is found near about 5.9 dB at 28 GHz. The 3D polar plot of the gain mentioned in Fig.3. The polar plot showed that the antenna has a dipole radiation pattern.

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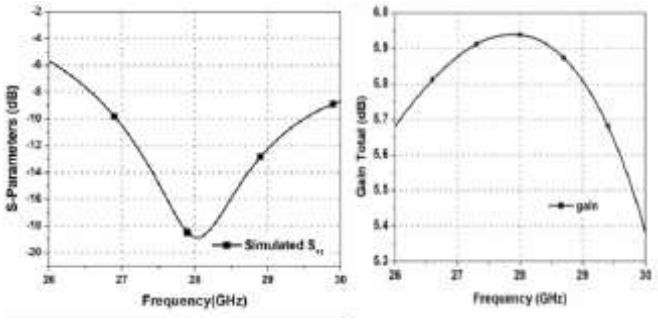


(a) (b)

Fig. 2.Simulated (a) S11 (d B) parameter and (b) gain versus frequency plot of Antenna 1

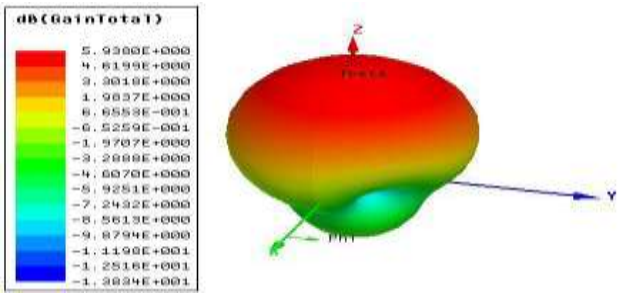


Fig. 3. 3D polar plot of Antenna 1 at 28 GHz

III. TWO ELEMENT MIMO ANTENNA DESIGN AND ANALYSIS

The two elements of the MIMO antenna depicted in Fig. 4. The space between two antenna elements taken near about W7=1.2mm and width of the antenna is W6=9.58mm. The simulated S parameters of the antenna shown in Fig. 5. The antenna covers a frequency band from 27.2 to 30.3 GHz. The S_{11} and S_{22} values are almost the same in the frequency ranges. The S_{12} is found near about <= -12 dB at frequency 28 GHz.

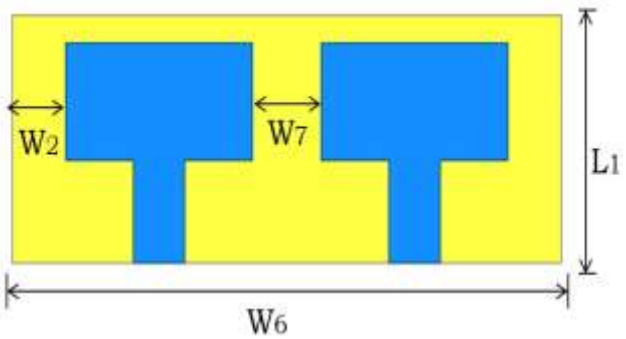
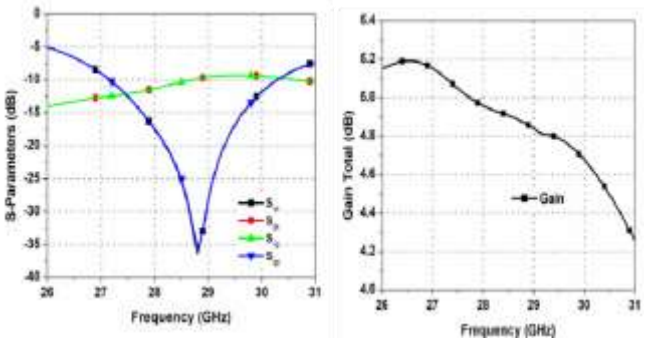
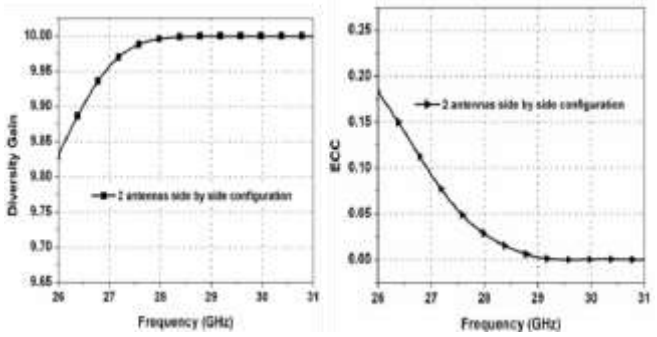


Fig. 4. Design Geometry of two elements MIMO



(a) (b)

Fig. 5. Simulated (a) S parameters and (b) gain Vs. frequency of two-element MIMO antenna



(a) (b)

Fig. 6.Simulated (a) ECC and (b) D.G parameter of the two-element MIMO antenna by considering port 1 and port 2

The Envelope correlation coefficient (ECC) and the Diversity gain (DG) are the two essential parameters of the antenna. The ECC and DG calculated using the radiation pattern method. The simulated ECC and D.G. parameter of the antenna is found near about <0.05 and >9.98 in the desired frequency ranges by considering port 1 and 2. The ECC and D.G. plot shown in Fig. 6.

IV. FOUR ELEMENTS MIMO ANTENNA DESIGN AND ANALYSIS

The four-element MIMO antenna designed and analyzed using ANSYS HFSS software. The MIMO antenna parameter calculated and four-element antenna performances are analyzed considering two different configurations.

A. Side by Side configuration

The design geometry of the four-element side by side configuration shown in Fig. 7. The space between antennas is W9=1.3mm, and the width of the overall antenna is W8= 18.8mm. The S-Parameters of the antenna shown in Fig 9. The antenna covers the spectra from 27.2 to 30.3 GHz. The gain is found near about 4.4 dB at 28 GHz, as shown in Fig 8.

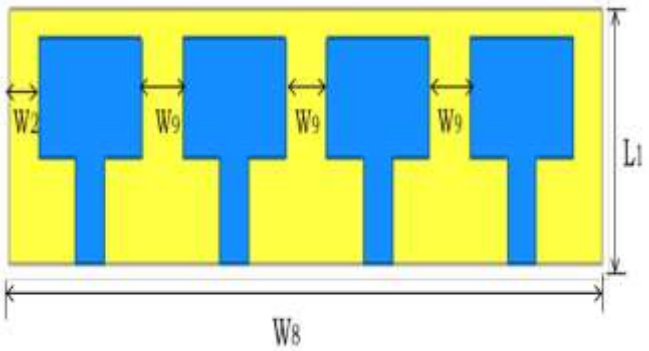
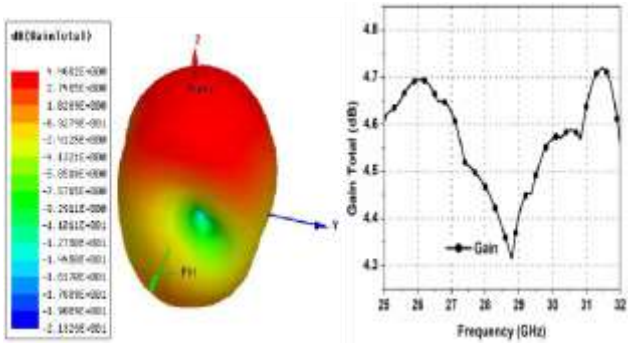
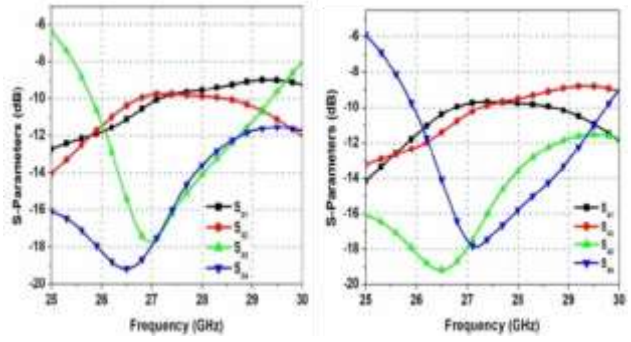


Fig.7. Design Geometry of four-element MIMO Antenna side by side configuration

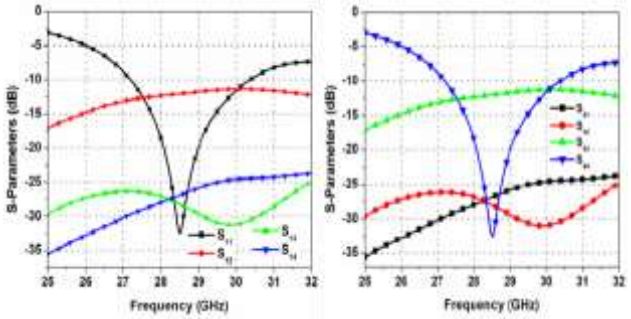


(a) (b)

Fig. 8. Simulated (a) 3D polar plot of the antenna at 28 GHz (b) Gain versus frequency of 4element side by side configuration of MIMO antenna



(a) (b)



(c) (d)

Fig. 9. (a-d) Simulated S parameters graph of the four-element side by side configuration of the MIMO Antenna.

B. Up-Down configuration

The design geometry of the antenna is shown in Fig. 10. The space between antennas is W11=L6=1.1 mm. The design parameters are L5=7.36 mm and W10=9.48 mm.

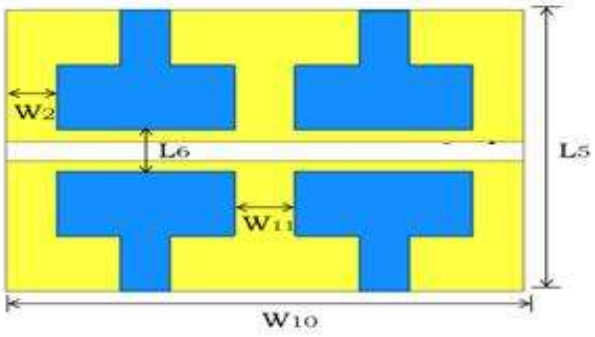
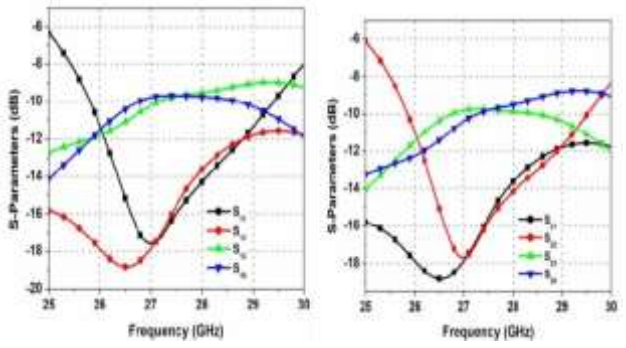
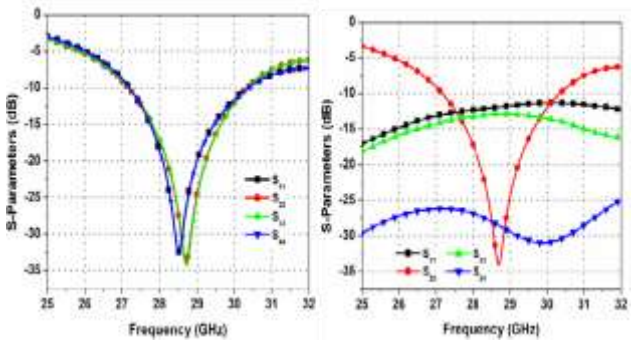


Fig. 10. Design Geometry of four-element up-down configuration MIMO Antenna



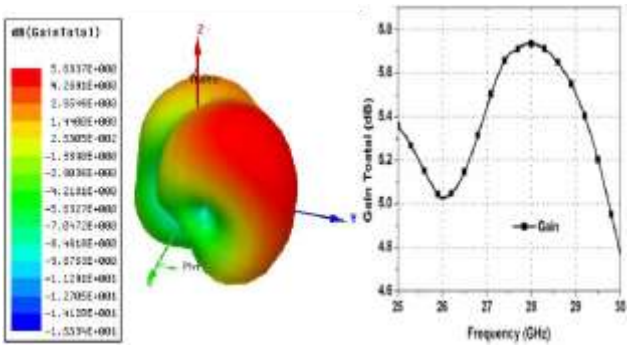
(a) (b)



(c) (d)

Fig. 11. (a-d) Simulated S parameters graph of the four elements Up-Down configuration MIMO Antenna

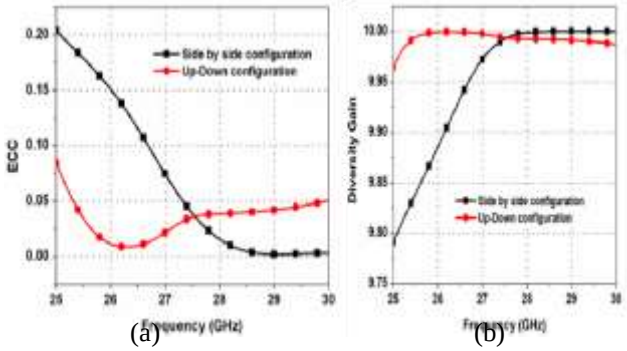
The S-Parameters of the antenna is shown in Fig. 11 (a-d). The antenna covers the frequency ranges of 25.8 to 29.4 GHz spectrum. The gain of the MIMO antenna is found near about 5.68 dB at 28GHz is as shown in Fig 12 (b). The 3D polar plot Fig. 12 (b) depicted that antenna radiation performance is affected due to MIMO.



(a) (b)

Fig. 12.Simulated (a) 3D polar plot of the antenna at 28 GHz (b) gain vs. frequency plot of 4elements Up-Down configuration of MIMO antenna

The comparisons plot of the ECC of both configurations mentioned in Fig. 13 (a) and (b). In both cases, the ECC found near about <0.05 in the desired frequency ranges. The DG also found near about >9.95 in both cases. So as per our application requirements, we can use the antenna.



(a) (b)

Fig. 13.Comparison of (a) ECC (b) DG of 4 element MIMO antenna in side by side and Up-Down configuration

V. CONCLUSION

In this article, a low-cost, compact four-element MIMO antenna for 5G applicationsdesigned and analyzed using ANSYS HFSS. This antenna covers the frequency band from 25.82 to 29.4 GHz with a gain of 5.7 dB. The ECC of the antenna is <0.1, and the DG of the antenna is > 9.0. This antenna covers the upcoming 5G application bands.

VI. ACKNOWLEDGMENT

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