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Design of Ultrawide Band Planar Monopole Antenna for MIMO Applications

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***Abstract*: This paper presents an ultrawide band planar monopole antenna in MIMO configuration. Initially a single element is constructed, composed of a bull-shaped monopole patch with three vertical (horn-like) stubs, tapered feed and partial ground plane. After that, two antenna system is used in the MIMO configuration. The simulated results in Computer Simulation Tool (CST) software show that antenna in MIMO configuration achieves S11, S12<-10dB over the wide bandwidth ranging from 3.1GHz to 10.6 GHz. Hence, the proposed antenna can be utilized over the unlicensed range in MIMO configuration for various applications. The simulated antenna is fabricated using FR4 substrate (Ɛ≈4.3) and the size of the antenna is 65mm*30mm*0.8mm.**

***Index Terms*: MIMO, monopole antenna, planar antenna, Ultra-wideband antenna.**

I. INTRODUCTION

As the available radio spectrum is finite, but the wireless/mobile communication (data consumption) is increasing exponentially day by day. And here ultrawide band (UWB) comes into play. UWB technology commits a little energy for short-range [1], high bandwidth communication over great percentage of radio band at very high data rates [2]-[4] and thus proving very useful in wireless communication for indoor purpose applications. But multipath interference can affect UWB transmissions. Hence, to overcome this problem and also increase transmission range and also improve reception reliability at the same time, Multiple-Input-Multiple-Output (MIMO) technique is utilised [4]-[5]. By means of multiple transmission and receiving antennas, MIMO helps in increasing the capacity of existing radio link. And now it has been standardized for wireless LANs, 3G& 4G mobile systems.

Monopole antennas have turned out to be one of the vital components of internet and mobile(wireless) networks all over the Earth. Also, their comparatively lower prices, ease of fabrication and swift installation makes it an apparent option [6]-[11]. At the same time planar antennas have become a lot popular due to their thin profile which can be incorporated into various consumer products. And hence due to their ruggedness and mobility we have gone with the planar monopole antenna.

In this project we have tried designing a compact ultrawide band monopole planar antenna consisting of a bull shaped radiator with three horn stubs. The simulation results show that the antenna is operable in the Federal Communication Commission (FCC) certified unlicensed range (i.e. 3.1-10.6 GHz). Description of antenna design and software simulation and measured results are presented to validate the proposed antenna's performance.

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II. ANTENNA DESIGN

A. Single Element Design

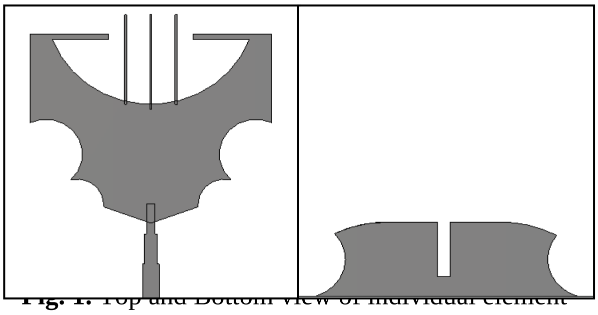

Fig. 1. Top and Bottom view of individual element

Fig.1 shows the single element design of total size 30mm x 30mm x 0.8mm along with element's reflection coefficient (S11 in decibel) in below figure Fig 2.

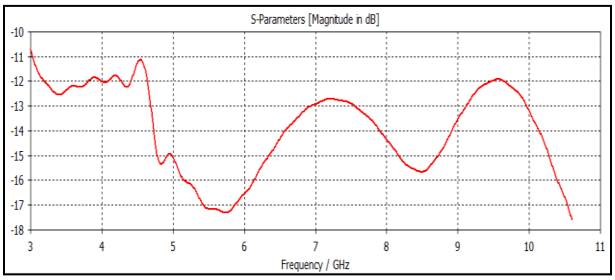

Fig. 2. Reflection Coefficient of individual element

The bull-shaped radiator has been obtained by carving out portions of the 23x17 rectangle. The portions are carved out to increase the path travelled by current across the radiator and for the similar reasons the three vertical stubs of size 9.5 x 0.2 are added on top of the radiator. This also helps in increasing the inductive loading of the overall element. We have also utilized tapered feed which has a width of 1.6mm near the port and 0.8mm at radiator to increase the current pressure at the radiator side. The minimum width of 0.2mm is maintained in overall design for the ease of fabrication.

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In order to decrease capacitive effect between radiator and ground, the ground plane was reduced from both the sides by notching out semi-circles of 4mm radius. The separation across the ground plane and the radiator, gap, is even crucial for matching impedance and the optimized gap is found to be 0.483mm.

B. Proposed MIMO Antenna Design

The MIMO (Multiple-Input-Multiple-Output) antenna proposed is illustrated by Fig. 3. The dimension of antenna are 30mm x 65mm x 0.8 mm and its constructed using FR4(lossy) substrate with dielectric constant of 4.32. The two elements are fed perpendicular to each other and kept orthogonally to one another. The two elements are placed such that they remain isolated to each other at a distance of 9.5mm to improve isolation attributes.

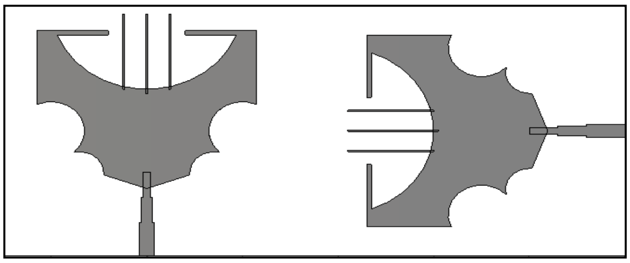

Fig. 3. Proposed MIMO (Multiple-Input-Multiple-Output) antenna design

III. DIVERSITY PERFORMANCE

The Diversity Gain and ECC (Envelope Correlation Coefficient) demonstrate the Multiple-Input-Multiple-Output (MIMO) antenna's diversity performance.0.5 is the acceptable value of ECC and can be evaluated by eq.(1) using the available S -parameters.

$$\rho = \frac{\left|S_{11}^{*}S_{12} + S^{*}_{21}S_{22}\right|^{2}}{\left(1-\left(\left|S_{11}\right|^{2}+\left|S_{21}\right|^{2}\right)\right)\left(1-\left(\left|S_{22}\right|^{2}+\left|S_{12}\right|^{2}\right)\right)} \quad (1)$$

The Diversity gain can be evaluated from eq.(2), the isolation attributes are determined by Diversity gain and ECC.

$$G_{diversity} = 10\sqrt{1-\left|\rho\right|^{2}} \quad (2)$$

The ECC obtained is less than 0.001 at all the frequencies as shown in the above figure Fig. 4.

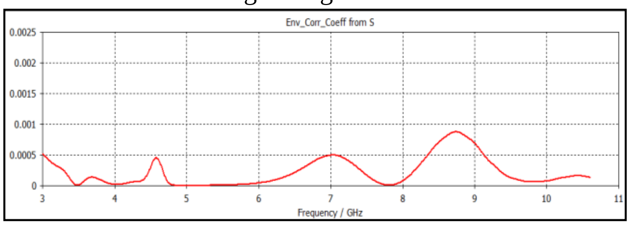

Fig. 4. Enveloped Correlation Coefficient (ECC)

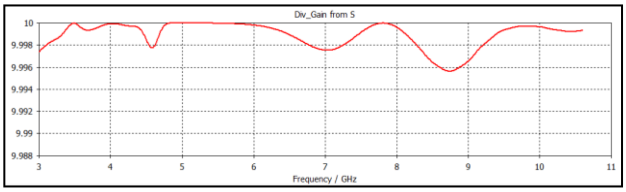

Fig. 5. Diversity Gain

Diversity gain is also a vital parameter for examining the isolation attributes. Fig. 5 shows the diversity gain of the design.

IV. RESULTS

A. Simulated Results

The software simulated scattering parameters of proposed MIMO (Multiple-Input-Multiple-Output) antenna are illustrated by Fig.6. The isolation among the two independent elements is improved because of polarization diversity attributes of the proposed MIMO (Multiple-Input-Multiple-Output) antenna and is below -20dB from 3GHz to 10.6 GHz.

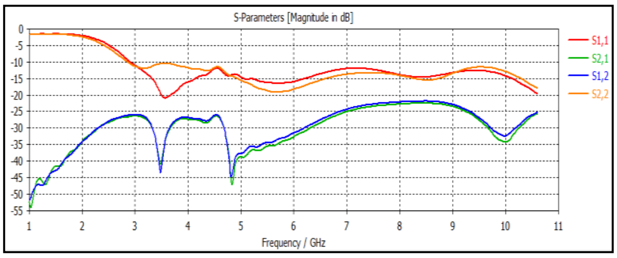

Fig. 6. CST Simulated S-parameters of proposed MIMO (Multiple-Input-Multiple-Output) antenna

B. Measured Results

The fabrication of the proposed MIMO (Multiple-Input-Multiple-Output) antenna was done and this was analyzed using Vector Network Analyzer (VNA). The fabricated antenna is shown in the below figure.

Fig 7. Top view of MIMO antenna prototype

Fig 8. Bottom view of MIMO antenna prototype

The measured output using VNA were a bit different from the simulated results. This might be due to a fabrication error as a wee-bit of soldering got on the partial ground plane and it could have affected the results. The measured S_{22} and S_{21} are shown below. The measured and simulated isolation were both below -20dB at all frequencies. But there was a difference in the results of S_{22}(insertion loss) which could have been due to above mentioned reason.

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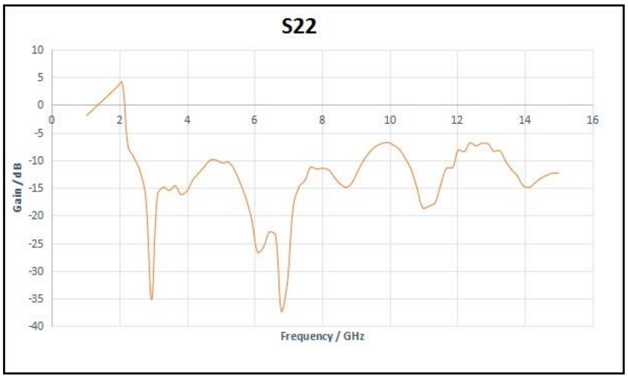

Fig 9. Measured S_{22} using VNA

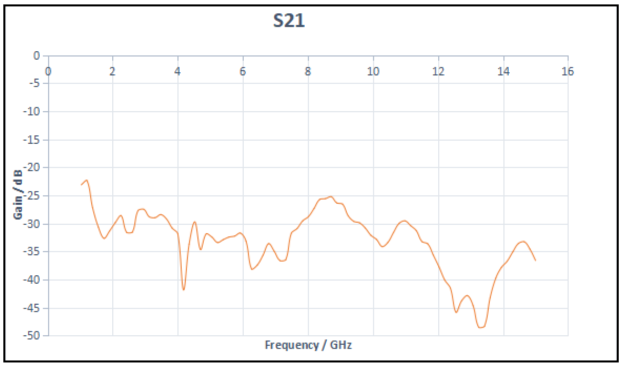

Fig 10. Measured isolation

S_{22}(Simulated v/s Experimental)		
Frequency (GHz)	Simulated (dB)	Experimental (dB)
3.1	-11.30	-16.21
3.6	-11.03	-14.63
4.1	-12.81	-13.56
4.6	-12.09	-9.99
5.1	-16.66	-10.49
5.6	-19.01	-14.07
6.1	-17.15	-26.68
6.6	-14.58	-23.45
7.1	-13.48	-18.56
7.6	-13.77	-11.26
8.1	-15.67	-11.73
8.6	-15.94	-14.29
9.1	-12.25	-11.88
9.6	-11.41	-7.52
10.1	-13.71	-7.28
10.6	-18.33	-11.69

Table 1. S_{22} experimental vs simulated

V. CONCLUSION

A dual element MIMO antenna was successfully designed for ultra-wideband applications. Instead of using normal feed a tapered feed was used to increase the current flow at radiator side. The orthogonally fed antenna helped in achieving a good isolation for MIMO antenna with isolation below -20dB for all the frequencies. ECC of 0.0008 is achieved by exploiting the polarization diversity characteristics. The partial ground plane helps the antenna to act isolated and reduce capacitive effect. The diversity gain of 9.995dB is achieved by orthogonally fed MIMO antenna. Hence, the above simulated diversity parameters show that a good MIMO antenna can be fabricated using the proposed antenna. Even the fabricated antenna's performance was quite similar to the proposed antenna if not for the small fabrication error.

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