Gain Enhancement of Modify 2x2 MIMO Antenna Using Superstrate Layer

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Abstract— In this paper, we present the gain enhancement of a microstrip MIMO antenna using a superstrate layer. The basic structure is a microstrip patch antennas consist of a metallic patch on one side of the dielectric substrate with ground plane on other side. The main aim of this paper is to obtain a high gain microstrip MIMO antenna. The antenna system consists of 2x2 radiating elements of same dimensions printed on a substrate. Superstrate layer has been designed to load the microstrip MIMO antenna. The unloaded MIMO antenna resonates at 5.8GHz with gain of 6.687dB. Whereas when loaded with the superstrate the gain increase to 9.428dBi which corresponds to gain enhancement 40.98%. This antenna can be used for Wi MAX. This structure are simulated and analysis using High Frequency Structure Simulator (HFSS) software.

Key words: MIMO Antenna, Superstrate Layer

I. INTRODUCTION

MIMO (Multiple Input Multiple Output) is one of the advance forms of microstrip patch antenna, whereas they use more than one radiating elements in order to enhance the antenna performance. MIMO is a part of modern wireless communications system such as 3G, 4G, WLAN/Wi Fi, LTE, Wi Max. It covers both the Wi MAX and Wi Fi, it can be used in other MIMO antenna applications. There has been a large requirement of antenna to transfer voice, data and multimedia information at very high data rate in RF communication systems. MIMO technique play a important role to achieved the improve the rates. [1]

Microstrip patch antenna is preferable due to its easy fabrications; it is studied extensively from past many years because of its light weight, low cost, small size and capability with standard manufacturing process. [2, 3, 4, 5]. However, in the MIMO antenna exists mutual coupling between the patch of the MIMO due to existence of surface wave, which degrades the performance of MIMO antenna parameters such as radiation chersterstics, bandwidth, gain, etc.[6,7]. Various techniques have been developed to enhance the gain of the MIMO antenna. Some of the most common method is U-shaped slotted patch antenna, different type of MIMO antenna and superstrate layer loaded antenna. [8,9]. The superstrate layer is a one technique to enhanced the performance of microstrip MIMO antenna in form of the gain. This method is known as the resonance gain methods and it utilized a superstrate with parameter of relative permittivity ε >>1 and relative permeability μ>>1. This gain varies proportionate to either μ or ε depending on the configurations. However, it was seen that gain is inversely proportionate to the bandwidth. [10]

This paper elaborates the design of superstrate layer modified 2x2 MIMO antenna using microstrip feeding which operate in the resonating frequency 4.5GHz. This antenna has been designed for Wi-MAX application.

II. ANTENNA DESIGN AND PERFORMANCE

"Fig.1 (a)" demonstrates the geometry of a 2x2 MIMO antenna whereas, and Figure 1(b) demonstrates the side view of 2x2 MIMO antennas. The presented MIMO antenna, resonating at frequency of 5.8GHz, is designed of a FR-4 substrate of thickness = 1.48mm, dielectric constant (ε_r) =2.5 and loss tangent =0.02. The width (W) and length (L) of the patch, as computed utilizing the "Eq. (1.1), (1.2), (1.3), (1.4)", are 19.54mm and 15.57mm, respectively. 50Ω SMA coaxial connector is utilized to feed the MIMO antenna. Table 1 demonstrates the different dimensions of the proposed MIMO antenna. The resonant input resistance of the rectangular patch antenna is 157.5Ω. The corporate feed technique is used to feed the MIMO antenna. This feeding network provides power splitting using quarter wave impedance transformer.[11] A quarter wave transformer of 88.74Ω is utilized for matching the 50Ω rectangular patch line. The width w of the quarter wave transformer and 50Ω line is calculated from.[11] is 1.55mm, 4.25mm. The length of quarter wave transformer is calculated is 5mm. the dimensions of the substrate are 40.57mm x 118.16mm. The length of feeding strip is 5mm.

$$W = \frac{C_o}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}} \tag{1.1}$$

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{-1}{2}}, \frac{W}{h} > 1 \tag{1.2}$$

$$L = \frac{C_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{1.3}$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \tag{1.4}$$

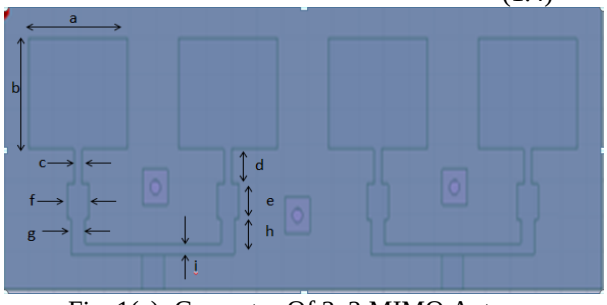


Fig. 1(a): Geometry Of 2x2 MIMO Antenna

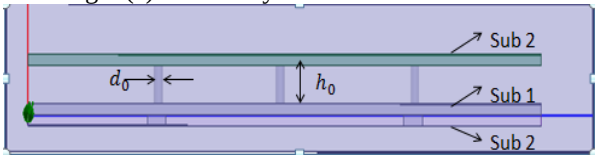


Fig. 1(b): Side view of an antenna

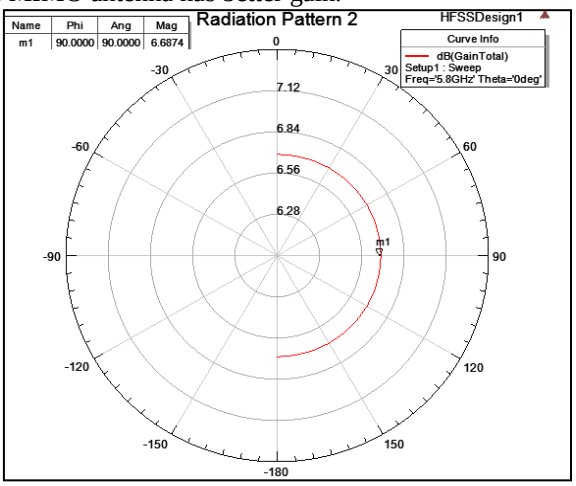
Parameters	Dimensions (mm)
a	19.54
b	15.57
c	1.55
d	5
e	5
f	4.25
g	2.7
h	5
I	1.55

Table 1: Dimensions of Proposed 2x2 Mimo Antenna

"Fig.1 (b)" shows side view of the 2x2 MIMO antennas, there are two superstrate layers are present in the design denoted by Sub2. The superstrate layers are designed on the FR-4 substrate of thickness 1.48mm, dielectric constant ε_r=4.5 and loss tangent=0.02. Upper layer of the superstrate are separated by the via, the height of the via is 5.17mm.[12]. The geometrical dimension of the superstrate layers are 40.57mm x 118.16mm. HFSS software is used to simulate this 2x2 MIMO antenna. The antenna measurements are done to validate the simulated results.

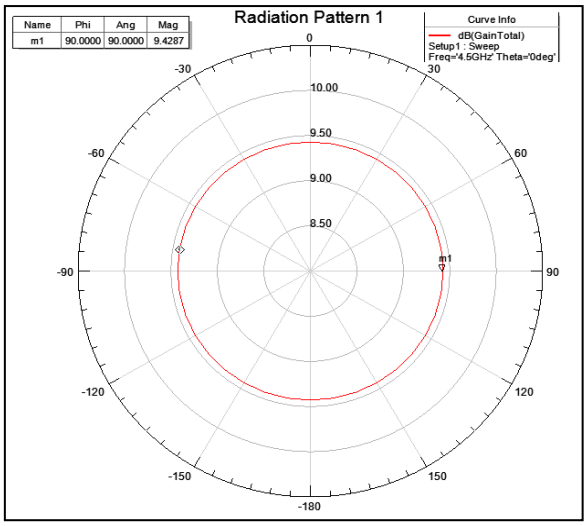
III. Result And Discussion

"Fig.2" demonstrates the radiation pattern of proposed MIMO antenna, the simulated result of proposed 2x2 MIMO antennas under the loaded and unloaded conditions are exhibited, the proposed antenna has been designed on FR-4 substrate. It is shows that the unloaded 2x2 MIMO antenna resonate ate 5.8GHz with gain of 6.687dB, whereas, when the proposed 2x2 MIMO antenna loaded with the superstrate layers, the gain of antenna increases to 9.824dBi, at the resonant frequency 4.5GHz, subsequently relating to the gain improvement of 40.98%. The Length and width of the MIMO antenna under both the conditions are same, but the height of the unloaded antenna is 1.48mm and loaded antenna height is 8.13mm. The height of antenna increased due to superstrate layers. Figure represents the azimuth plane radiation pattern of loaded or unloaded antenna. It is sutable for Wi MAX application. "Fig.3" demonstrates the 3D polar plot which is obtained from the HFSS software. The proposed microstrip 2x2 MIMO antenna has better gain.



Azimuth Plane Gain Display (dB)

Fig. 2(a): Azimuth plane radiation pattern characteristics an unloaded MIMO antenna.



Azimuth Pattern Gain Display (dBi)

Fig. 2(b): Azimuth plane radiation pattern characteristics of loaded 2x2 MIMO antenna.

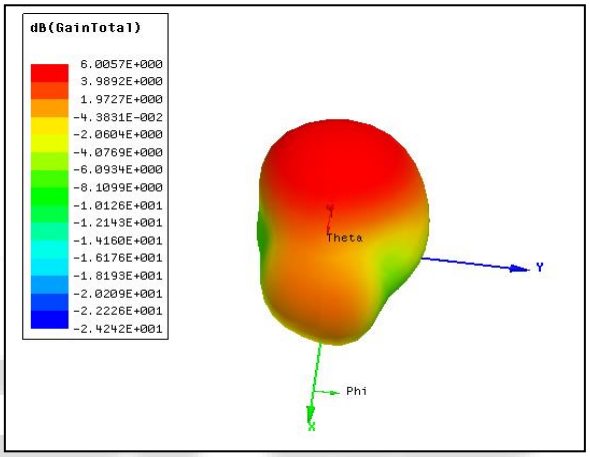


Fig. 3: 3D polar plot of proposed 2x2 MIMO antenna.

"Fig.4" Demonstrates the return loss plot of proposed 2x2 MIMO antenna. It is observed that with superstrate layer, the S_{11} is less than -19.13dB from 4.45 to 4.59 GHz. "Fig. 5" Show mutual coupling plot of the proposed 2x2 MIMO antenna. It is observed that, the S_{21} or S_{12} is less than -14.739dB, at the antenna resonating frequency 4.5GHz.

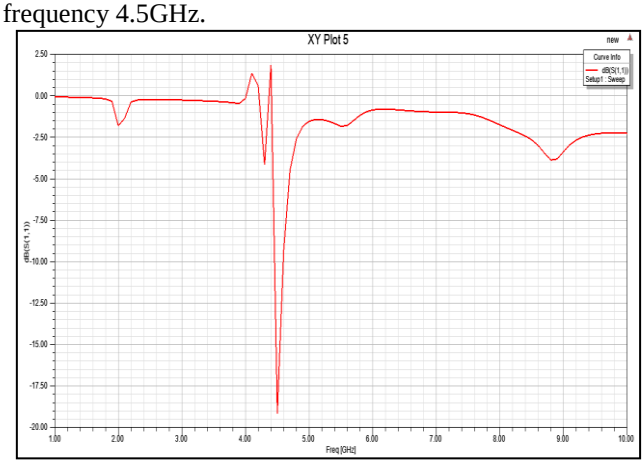


Fig. 4: Return loss Vs. frequency of 2x2 MIMO antennas
Freq =4.5GHz S_{11} = -19.13 dB

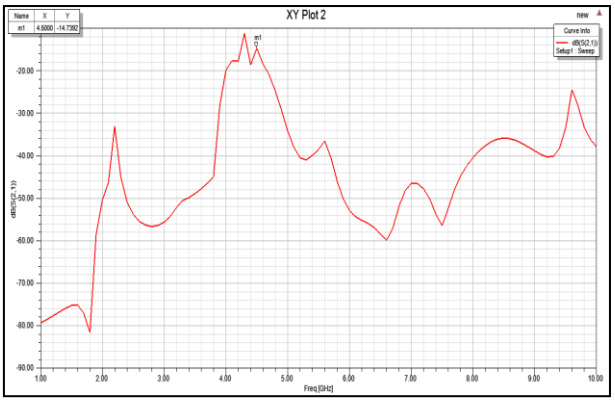


Fig. 5: Simulated S_{12} or S_{21} parameter Freq =4.5GHz, S_{12}=S_{21}=-14.739

IV. CONCLUSION

The superstrate layer loading has been proposed to improve the gain of an antenna system for MIMO applications. The proposed antenna has been designed on FR-4 substrate to achieve the high gain. When the conventional microstrip 2x2 MIMO is loaded with the superstrate layers, gain improves by 2.741dB. The advantage of this proposed antenna is that its execution gets enhanced by including superstrate layers. The superstrate layers are spaced away from the patch, the loading effect on the antenna are reduced. The proposed antenna has been designed for Wi-MAX applications.

V. FEATURE SCOPE

Based on the conclusions and limitations regarding gain, there is a scope to enhance the gain, bandwidth and the mutual coupling between the antenna elements of microstrip 2x2 MIMO antenna. Metamaterials or different type of substrate with different dielectric constant and thickness can be enhanced antenna parameters.

REFERENCES

[1] L.chouti, A.behloul, I. Messaoudene, "Numerical Analysis of a Microstrip MIMO Antenna Array" IEEE Symposium on Mediterranean Microwave pp.1-4, Dec 2014.
[2] Girish Kumar and K.P. Ray, Broadband Microstrip antennas, Norwood Artech House 2003.
[3] Ramesh Garg, P. Bhartia, Inder Bahl, A. Ittipiboon, Microstip Antenna Design Handbook, Artech House,2000.
[4] C. A. Balanis, "Antenna Theory, Analysis and Design," John Wiley & Sons, New York, 1997.
[5] Ali, Zakir; Singh, Vinod Kumar; Singh, Ashutosh Kumar; Ayub, Shahanaz; "E shaped Microstrip Antenna on Rogers substrate for WLAN applications", IEEE Conference on Computational Intelligence and Communication Networks, pp342-345, Oct 2011.
[6] Guohua Zhai, Zhi Ning Chen, "Mutual Coupling Reduction of a Closely Spaced Four-Element MIMO Antenna System Using Discrete Mushrooms", IEEE Transactions Microwave Theory and Techniques, Vol. 64, No.10, pp.3060-3067, Oct 2016.
[7] Dandker, K.R., H. Ling, and G. Xu, "Effect of Mutual Coupling on Direction Finding in Smart Antrenna Applications", Electronics Letters, Vol. 36, No. 22, 1886-1891, 2000.
[8] W. Swelam and M. Ali Soliman,"Compact Dual-Band Microstrip Patch Array Antenna for MIMO 4G Communication Systems", IEEE International Symposium on Antennas And Propagation Society, pp. 1-4, 2010.
[9] Kanika Joshi, Srishti Saraswat, et al."Superstrate Layer in Patch Antenna A Review", International Journal in Latest Trends in Engineering and Technology, Vol 6, Issue 2, pp. 340-345, 2015.
[10] David.R.Jackson and Nicolos G.Alexopoulos, "Gain Enhancement Method for PrintedCircuit Anteenna", IEEE Transection on Antenna and Propagation, Vol. 33, No.9, September 1985.
[11] Pozar.D, Microwave Engineering, John Wiely & Sons, New York, NY, USA, 2008.
[12] Ashok Kumar, Garima Saini, "A Review on Feature Planar Transmission Line", Electrical and Electrical Engineering Review Article, pp. 1-12

