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DESIGN OF 4 ELEMENT BASED MIMO SLOT ANTENNA

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Abstract: A Four element slot based Multiple Input Multiple Output(MIMO) antenna is presented. The antenna elements are planar in structure and designed on a single substrate. The substrate used for antenna design is FR4 epoxy with a dielectric constant of 4.4 the dimensions of the dielectric is 42×25×1.6mm3. The antenna design is optimized to cover various frequency bands from 4.2~7.2GHz making it applicable for WLAN. The proposed antenna is suitable for communication applications. The simulation of the antenna has been performed using High Frequency Structure Simulator (HFSS). The maximum measured gain of the antenna is 1.8dB. The envelope correlation coefficient (ECC) did not exceed .248 in the entire operating band of the MIMO antenna.

Keywords*:* Multiple Input Multiple Output(MIMO), HFSS.ECC,WLAN,VSWR

I. INTRODUCTION

In communication system, Wireless technology has popularly increased and Antenna has become one of the important part of these system. Wireless local area network (WLAN) and the Worldwide Interoperability for microwave Access (Wi-MAX) technology is speedily growing area in the modern wireless communication system. This provide user to flexibility to move in a broad coverage area and still be remain in the network, which bring freedom and tractability. Wireless has become popular due to ease of installation and for these application we require antennas. Handy antenna technology has rapidly grown along with mobile and cellular technologies. It is important to choose appropriate antenna for the device. Proper antenna installation will definitely improve transmission and reception. The Analysis of communication system without understanding the design and fabrication of antenna is incomplete.

The communication industry mainly focused on high data rate. High data rate requirements can be achieved by using multiple input multiple output(MIMO) system. MIMO systems are capable of transmitting and receiving signals of same power levels in parallel channels. They have low bit error rate and maximum capacity. MIMO systems increase the channel capacity by utilizing the same power and spectral efficiency compared to the SISO (single input single output) systems. [1,2]. Printed monopole antennas are good choice due to its characteristics like simple, low profile and compact size.

Many MIMO antennas have been reported in literature for WLAN applications [3]- [6]. Both printed and non-printed such as planar inverted F antennas are proposed. Among this printed antenna are more appropriate for small terminal devices. Due to their low cost and ease of fabrication . In [3] a micro strip line fed antenna with quarter wave length slots, which radiates 2.5GHz and 5.6GHz. To achieve good isolation, it uses a simple decoupling network based on a wide slot and a pair of narrow slot. Similarly, in [4] an antenna is designed and operates at 2.4GHz. Here, to provide an isolation between the ports a decoupling network is added in to the circuit, and a slot is etched on the ground. In [5] a monopole based C-shaped antenna with a L-shaped parasitic strip on the ground plane. The antenna can cover a wide range of frequency from 2.1-6GHz, which are allocated for WLAN and WiMAX application. In [6] two octagon shaped monopole antenna placed perpendicular to each other. Which covers a wide range of frequency bands from 3.1-10.6GHz. This antenna is suitable for portable UWB applications.

The proposed antenna is wideband square planar monopole antenna, which covers a frequency range from 4.4-7.2GHz. The antenna is of reduced size due to its planar structure and can be used for short distance communication. the proposed antenna system was realized on a substrate of 42×25×1.6mm3. All the antenna elements are on a single substrate. Electromagnetically coupled feeding technique is used to feed the antenna elements.

II. ANTENNA DESIGN

A. *Geometry of MIMO antenna*

In this work, 4-element antenna has been designed for MIMO systems. The geometry of a single element as shown in **F**ig:I.Table1 shows the optimized numerical values of the antenna structure in millimetres. The base element is

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rectangular slot antenna. The feed lines are electromagnetically coupled with the patch. the simulated result of base element as shown in figure 2. The graph shows that the single element can cover a wide frequency band.

The antenna system consists of a four rectangular patch antennas. All the antenna elements are on a single substrate. Full ground plane has been used, common ground for all the four elements. Here the surface current shared among the antenna elements and the ground plane, whereas the surface waves can be neglected as thin substrate has been used. To achieve least mutual coupling set the distance between the antenna elements [6]. The rectangular radiation patches are printed on the top of the substrate the feed lines are on the back side of the substrate and electromagnetically coupled to the patches. The electromagnetically coupling helps in the band width enhancement. [7].

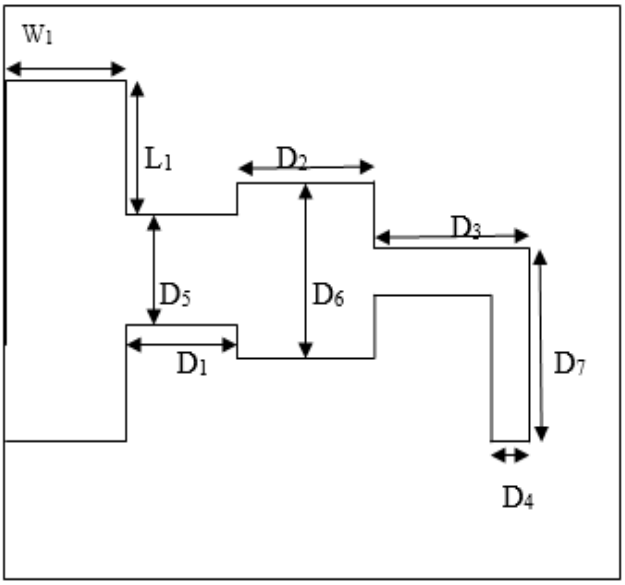
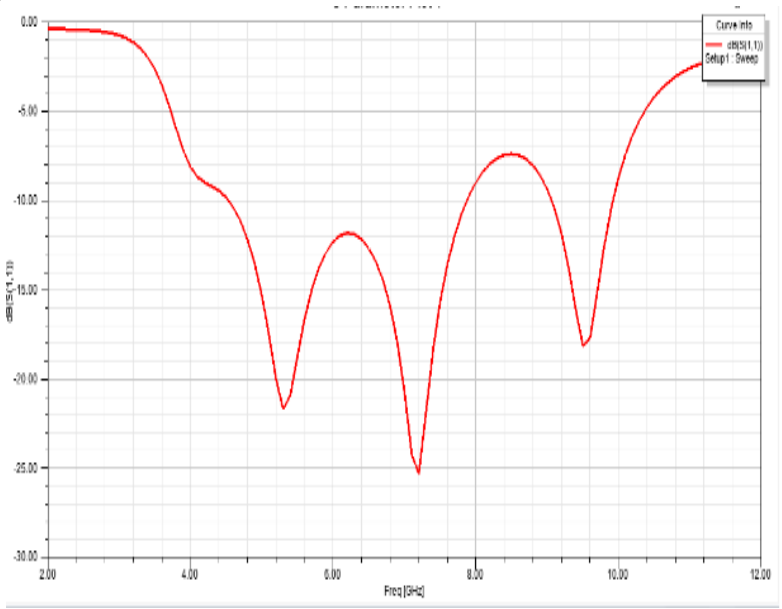


Fig: I - The Base Structure

B. *Four element MIMO antenna*

The four element slot base MIMO antennas as Ant_1, Ant_2, Ant_3, Ant_4 and they are excited by Port-1 Port-2 Port-3 Port-4 as shown in fig II(a,b).The substrate used for antenna design is FR4 epoxy with relative permittivity **4.4.** The thickness of the substrate is 1.6mm. The isolation between the antenna elements can be improved by increasing the spacing between them.



.Fig: II- Simulated S11 Parameter of Base Element

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(all values are in mm)

PARAMETER	VALUES
L_1	1.6
W_1	2.3
D_1	1.1
D_2	1.6
D_3	1.7
D_4	0.4
D_5	0.9
D_6	1
D_7	2.9

Table 1 - Numerical Values of Antenna Structure

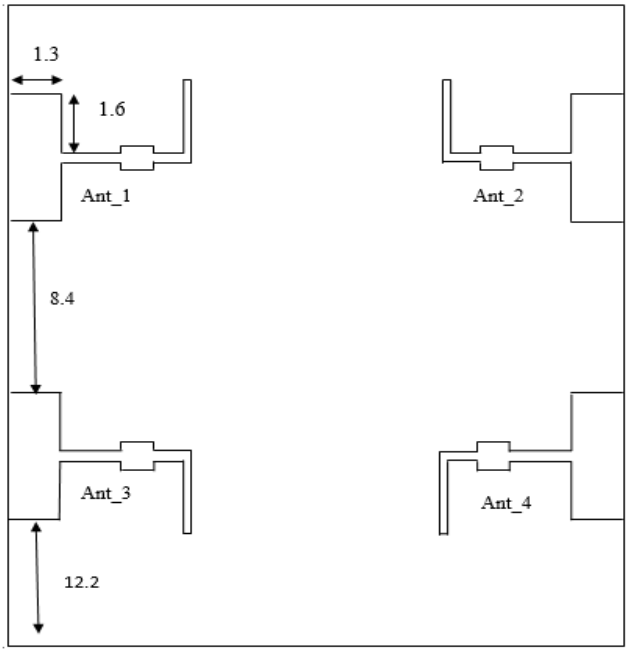

Fig:II(a**)** - Top View of the Proposed Antenna

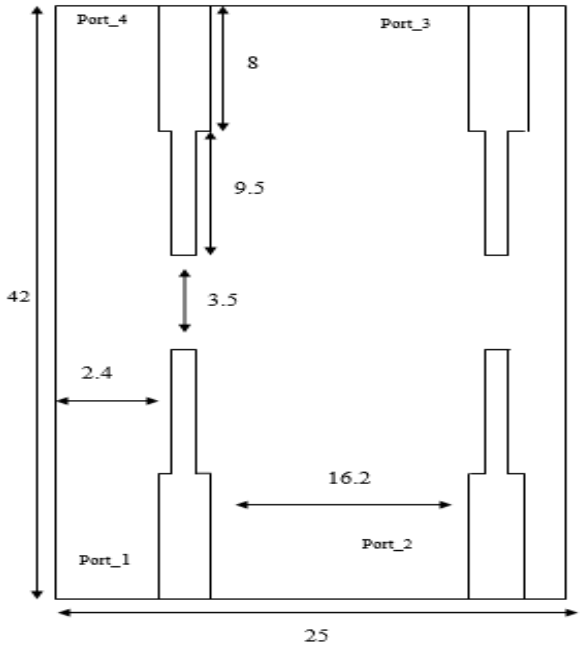

Fig: II (b**)** - Bottom View of the Antenna

III.RESULTS

The four element slot based MIMO antenna was modeled and simulated using HFSS **v.19**.Fig: III shows the effect of mutual coupling on the antenna elements. Mutual coupling is basically the electromagnetic interaction between the elements in an antenna, which causes the changes in the radiation pattern and the current distribution. In MIMO system the antenna elements are designed in a way the correlation between the elements should be minimum. The S-parameter graphs are identical because of the four antenna elements are identical. Figure shows it provide a better isolation between the antenna elements.

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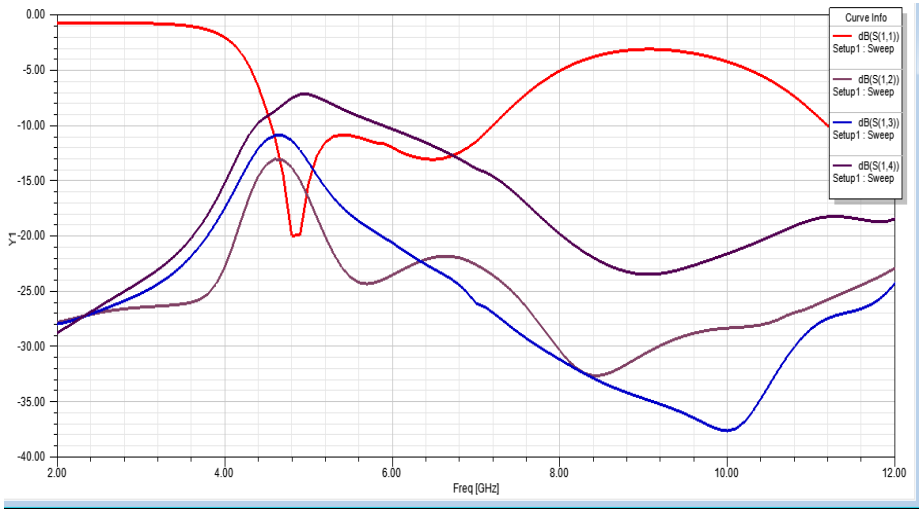

Fig: III (a) - Effect of mutual coupling on 1st element

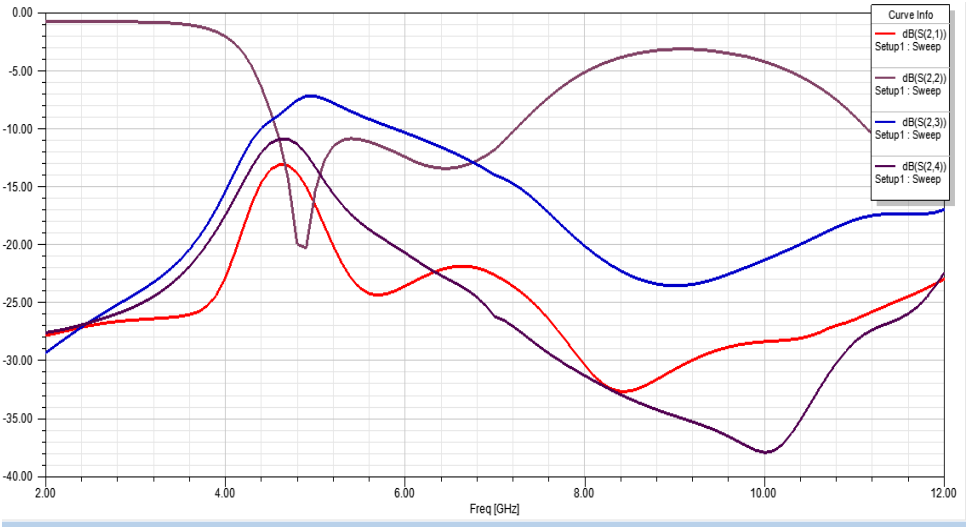

Fig: III (b**)** - Effect of mutual coupling on 2nd element

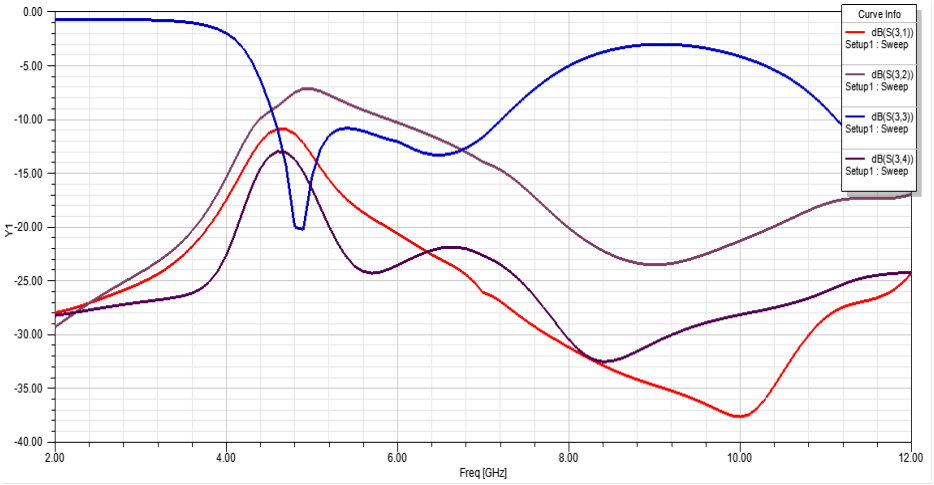

Fig: III ©- Effect of mutual coupling on 3rd element

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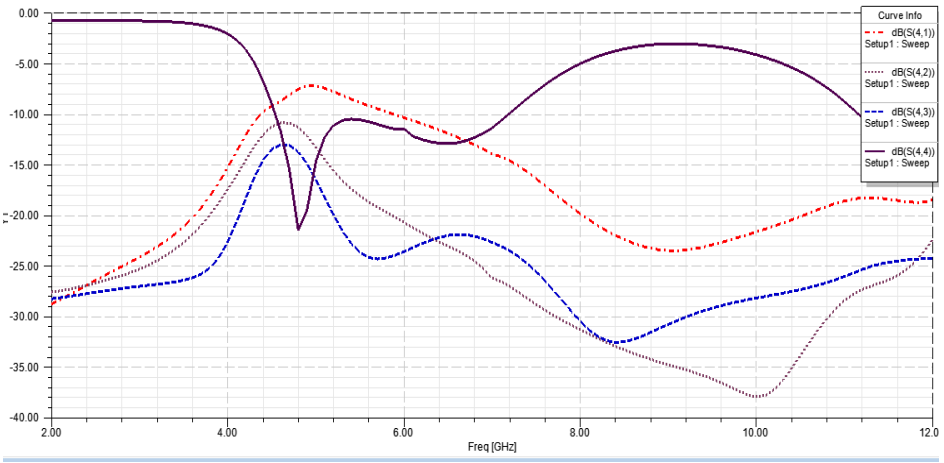

Fig: III (d)- Effect of mutual coupling on 4th element

Fig IV shows the 3D gain pattern of the antenna. All the MIMO elements are terminated with **50**-ohm load. The maximum gain of the antenna is **1. 89dB.**

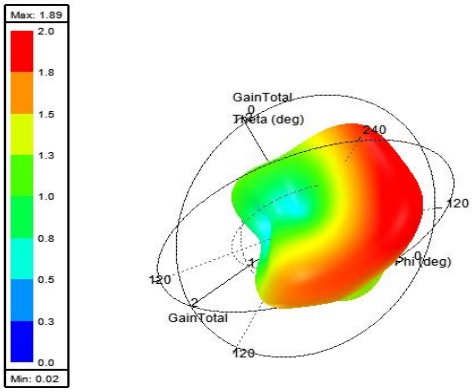

Fig:IV-Simulated 3D gain pattern. Maximum gain **1.89 dB**

The radiation characteristics of the proposed antenna system are investigated in the operating frequency range of **4.4-7.2 GHz.** The radiation patterns are obtained at one port, while terminating the other port at 50 Ω load. The radiation pattern in two principle planes are shown in the Fig:V ie. the E and H plane radiation patterns are shown. The E and H-plane radiation patterns are directional. E- plane corresponds to phi=00 and H-plane corresponds to phi=900 that is the XZ plane corresponds to E- plane and YZ corresponds to H-plane.

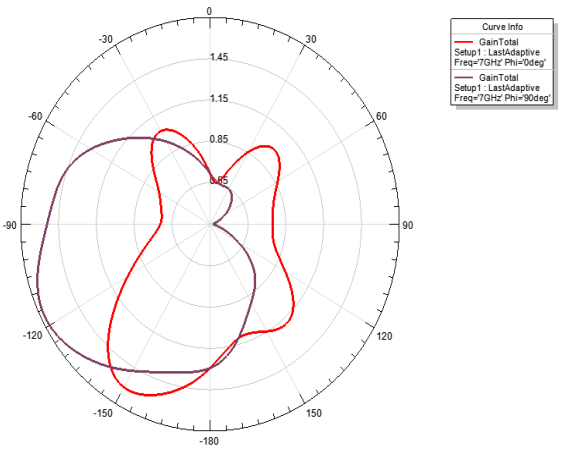

Fig :V - Simulated radiation pattern of proposed antenna

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For a MIMO antenna Envelope Correlation Coefficient (ECC) is an important parameter, which indicates its diversity performance. An approximated expression of ECC for any practical lossy MIMO antenna in terms of S parameter is given by [10]

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

$\eta_{rad,i}$ and $\eta_{rad,j}$ are the radiation efficiencies of the i^{th} and j^{th} antenna respectively. The ECC value of the proposed antenna is less than **0.248**. So the proposed antenna provides a good spatial multiplexing. Fig: VI shows the graph between the ECC values with frequency.

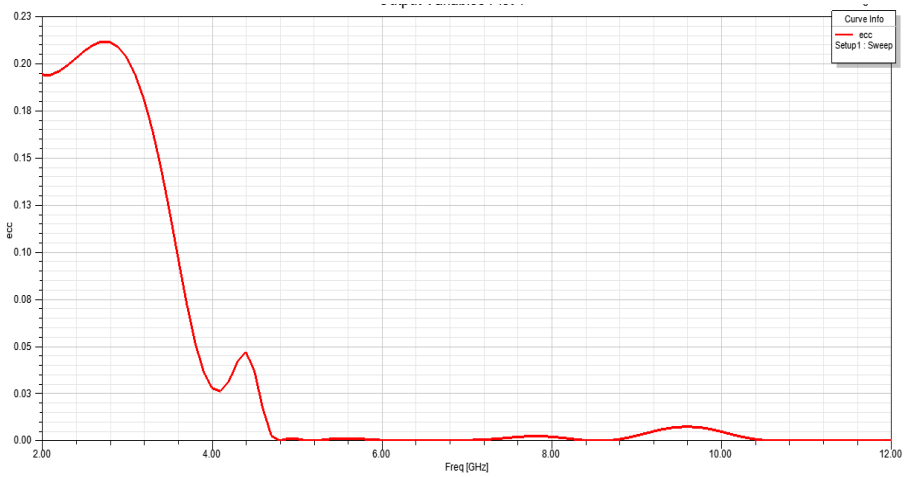

Fig:VI - ECC of the proposed antenna

VSWR of the proposed antenna is shown in the**Fig:**VII . For high impedance matching, VSWR≤ 2. In the proposed antenna it is less than 2 in the frequency range of 4.4-7.2GHz. VSWR describes the power reflected from the antenna.

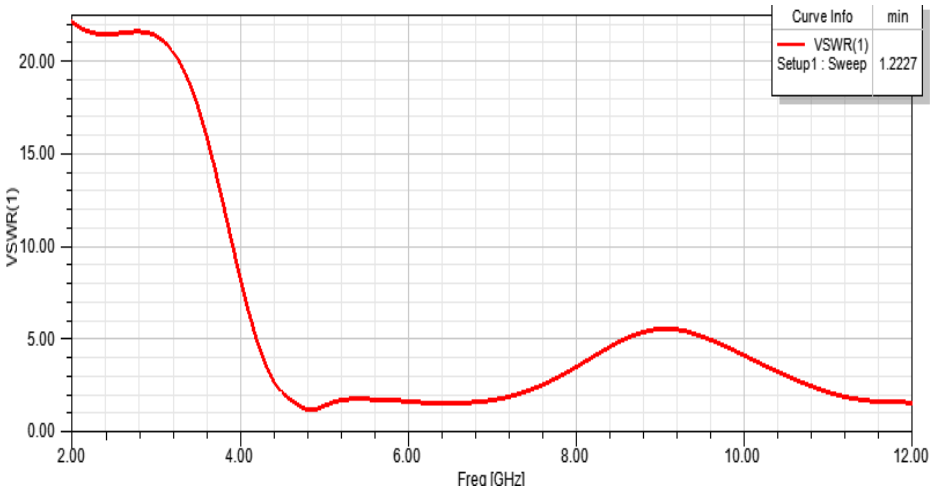

Fig:VII - VSWR of the proposed antenna

CONCLUSION

A compact four elements slotted MIMO antenna is designed and operating at a wide band frequency range. it can be seen that the simulated results can cover a frequency range from 4.4-7.2GHz with S_{11}≤-10dB. The ECC parameter

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shows that it provides a good isolation between the antenna elements. ECC values are less than 0.248. The isolation is achieved by without using any decoupling methods.

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