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MUTUAL COUPLING EFFECT ON MIMO ANTENNA

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Abstract - To reduce mutual coupling effect on MIMO Antenna this paper presents the analysis of bent ground plane antennas for multiple-input-multiple-output (MIMO). First, the three plate antenna array patterns of the envelope correlation coefficients are proposed to evaluate the diversity performance of antennas in MIMO systems. Following this, a compact three-element suspended plate antenna array with a bent ground plane is presented. The diversity performance of the design is experimentally and numerically analysed.

Keywords - *Antenna array, correlation, diversity methods, multiple-input-multiple-output (MIMO) systems, mutual coupling.*

I. INTRODUCTION

Conventional Microstrip antenna has a conducting patch Printed on a grounded microwave substrate and has the Attractive features of low profile, light weight, easyfabrication and is conformable and to improve the gain MIMO system is use.

This paper first describes the performance evaluation of antennas in MIMO system. After that, a three-element suspended plate antenna design with a bent ground plane is presented as an example and analysed.

The development of wireless multimedia technology has raised the capacity and reliability requirements of wireless communication systems. It has become increasingly difficult to fulfil these requirements with traditional SISO (single-input single-output) systems, due to the limitations in channel capacity. By using transmitting-diversity, diversity-reception, and channel-coding techniques, MIMO (multiple-input multiple-output) systems are able to transmit multiple decor-related signals, with the same power level, simultaneously through spatially parallel channels. These signals are then received and combined using diversity techniques. MIMO has been accepted as a promising technology for its potential to achieve low bit error rate (BER) by space time coding or to achieve large capacity by multiplexing. MIMO multiplexing has been widely adopted to realize high speed data Communications. Multiple-Input and Multiple-Output, is the use of multiple antennas at both the transmitter and receiver to improve communication performance.

One of the main benefits of MIMO systems over traditional SISO systems are their improved capacity and reliability, without increasing transmitted power or bandwidth. In a MIMO system, the antennas not only have a great impact on the system's received channel capacity, but they also play an important role in system stability. To achieve these, the antenna arrays used in MIMO systems are required to have high gain, a wide lobe pattern, and high isolations between antenna elements.

CADFEKO is one of the most imperial electromagnetic software which allows to solving for radio and microwave application. It works based on method of moment (MOM). The simulator tool computes most of the useful quantities of interest such as VSWR, return loss radiation pattern, input impedance and gain etc.

II. FEED METHODS

There are various feed methods which are categorised as Contacting or Non contacting .The contacting methods include coaxial or probe feed and inset feed, whereas the non contacting include proximity feed and aperture coupled feed. The coaxial or probe feed is very common method for feeding Microstrip patch antennas. The inner conductor of coaxial connector extends through the dielectric and is soldered to the radiating patch while outer conductor is connected to the ground plane. The advantage of this method is that feed can be placed at any location inside patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

III. EVALUTION of MIMO ANTENNAS

On the top of the conventional parameters to evaluate the RF performance of antennas such as impedance matching, gain, radiation patterns, and polarization, the envelope correlation coefficient between antennas can be used to evaluate the antenna array design in MIMO systems from the system perspective. The envelope correlation coefficient can be calculated using S-parameters or radiated electric fields assuming that the antennas are lossless and the channels are uniform and random. Using the S-parameters of N elements, the envelope correlation coefficient, $\rho_{e,ij}$ can be given as:

$$\rho_e(i,j,N) = \frac{\left|\sum_{n=1}^{N} S^{*}_{i,n} S_{n,j}\right|^2}{\prod_{k=i,j}\left[1 - \sum_{n=1}^{N} S^{*}_{k,n} S_{n,k}\right]}$$

Where, i and j indicate the i^{th} and j^{th} elements, respectively. It can be observed that the correlation is affected by the inter-element mutual coupling, impedance matching and the phase difference between S_{ii} and S_{ij} . From the denominator term it can be observed that S_{ii} and S_{ij} also affect the overall radiated power from all the elements. As a result, both factors have a direct effect on the antenna efficiency. The periodic variation in the envelope correlation coefficient shows is caused by the phase change in the numerator term.

IV. ANTENNA SYSTEM DESIGN

The proposed antenna system consists of three identical suspended plate elements ($l \times W$) as shown in Fig. 1.

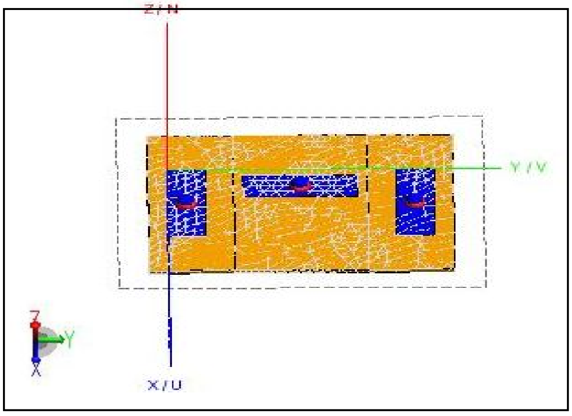


Fig. 1: MIMO system.

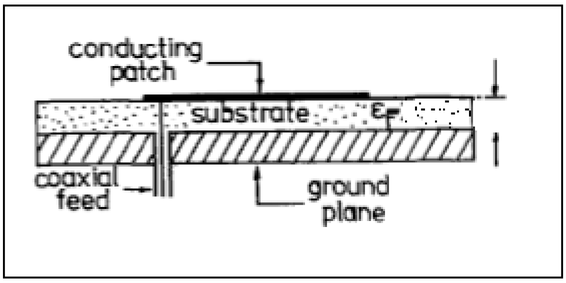


Fig. 2: Geometry and feeding arrangement of Microstrip antenna With coaxial feed

The antenna system was configured such that Elements 1 and 3 were parallel to each other and Element 2 was perpendicularly placed between them. The ground plane was then bent along the dotted line as shown in fig.1, the physical structure of bent ground plane antenna array shown in fig 3. The corresponding effects of the bending angle on the mutual coupling, radiation pattern, were examined at $\alpha = 0^0$,45^0.

For all the antennas the feeding method used is coaxial feed.

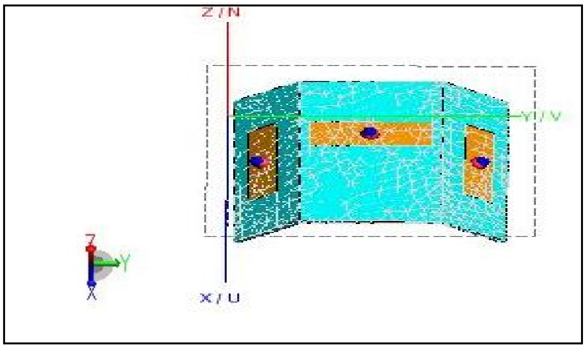


Fig. 3 : Suspended MIMO System

V. RESULTS AND DISCUSSION

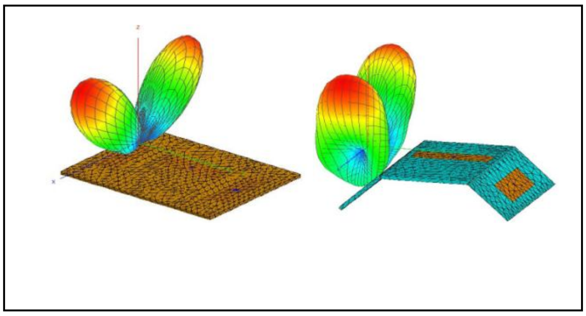


Fig. 4: $\alpha = 0^0$. **Fig. 5: $\alpha = 45^0$.**

From above diagram it is found that the results are closely related with mutual coupling factor. For better result, we fixed various parameters like feed position, dielectric constant, height of dielectric, patch size at optimum level and changing only the angle of ground plane for further analysis.

Figure 4 & 5 shows physical structure of MIMO antenna with radiation pattern without bending the ground plane and with bending respectively.

First, we simulate antenna system without bending ground plane i.e. $\alpha = 0^0$ and It is observed that the structure hardly affects the impedance matching. Also check the effect of mutual coupling at resonance frequency 4.76 GHz.

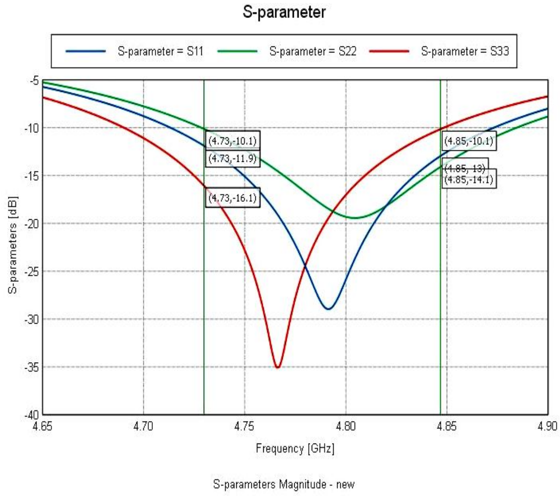
In iteration, the portions of the ground plane are bent i.e $\alpha = 45^0$ as shown in figure 5, the mutual coupling between Elements 1 and 2 is found to be reduced such that the lowest coupling is achieved. The similar trend is also demonstrated for Elements 1 and 3. However, the mutual coupling between Elements 2 and 3 is also reduced. The correlation can be significantly reduced between Elements 1 and 2 as well as Elements 1 and 3 when $\alpha = 45^0$.

All the results are shown in table 1.

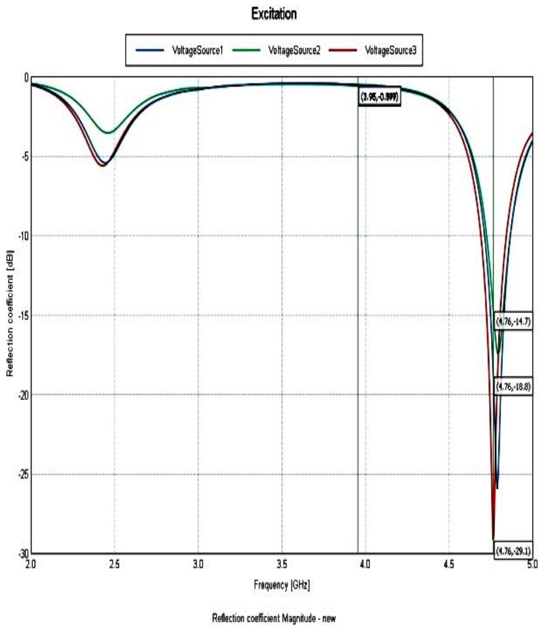
Resul s	A1-P1	A1-P2	A1-P3	A2-P1	A2-P2	A2-P3

Band width	200M Hz	200M Hz	200M Hz	200M Hz	200M Hz	200M Hz
Resonant frequency	4.76 GHz	4.76 GHz	4.76 GHz	4.76 GHz	4.76 GHz	4.76 GHz
Reflection coefficient	-18dB	-14dB	-29dB	-30dB	-16dB	-40dB
VSWR	1.4	1.6	1.2	1.3	1.3	1.2
Gain	2.32			1.61		
Impedance	64	84	79	55	75	57

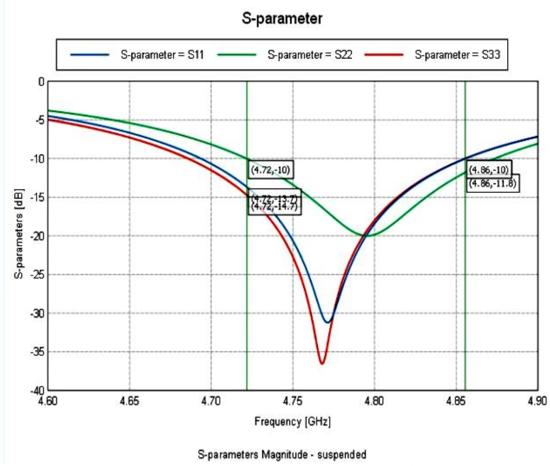
Table 1 : complete result of both array at $\alpha = 0^0$ & $\alpha = 45^0$



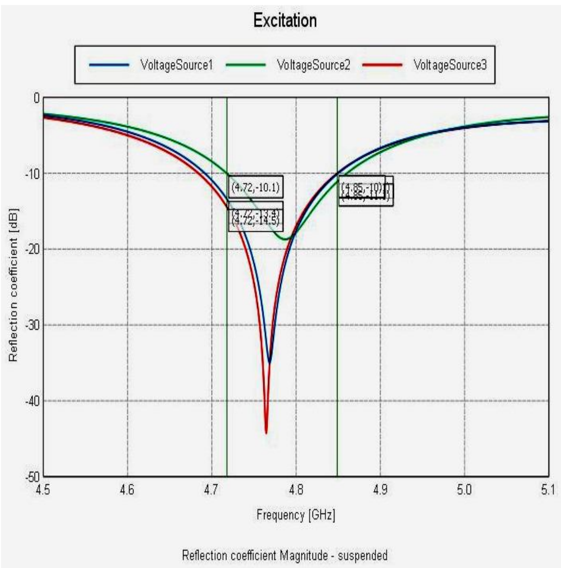
S-parameter of array at $\alpha=0^0$



Reflection coefficient at $\alpha = 0^0$



S-parameter of array at $\alpha=45^0$



Reflection coefficient at $\alpha = 45^0$

VI. CONCLUSIONS

Two antenna array are investigated in this paper for the both antenna array the substrate used is FR4 substrate with thickness h=3mm the results show that for the second antenna array at $\alpha = 45^0$ having less reflection of signals as compare to antenna array at $\alpha = 0^0$, the reflection is reduces because of mutual coupling factor. So by using a bent ground plane we can minimize coupling effect in MIMO system.

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