Four Element Antenna Array using MIMO Technology with Improved Bandwidth and Isolation

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Abstract : **The ever increasing demand for high data rates drives the wireless communication standards towards incorporation of multi input multi output (MIMO) technology. For such systems, the designed antenna must be compact with low profile configuration, good impedance bandwidth and low mutual coupling. In this paper, a compact two-element microstrip antenna operating from 5.8–10 GHz is proposed for wireless applications. The simulated antenna resonates at 7.5 GHz frequency, with a 10 dB fractional impedance bandwidth of 45.33% and voltage standing wave ratio (VSWR) of 1.15. The mutual coupling is reduced to around 18 dB at the resonant frequency. For the proposed antenna return loss at 7.5 GHz is 23 dB. The antenna system has a radiation efficiency of 110.16% at the center frequency. The performance of the proposed antenna array is better than the existing microstrip antennas in terms of fractional impedance bandwidth and isolation.**

IndexTerms - ***Micro strip patch antenna, mutual coupling, antenna array, Bandwidth, radiation efficiency, E-shape patch, U- shape patch.***

I. INTRODUCTION

In the current advanced wireless communication, Multiple Input and Multiple Output (MIMO) system plays an important role to meet the requirements of high speed data rates [1]. Due to rapid development of wireless mobile communication the need of high speed data transfer with multiband operations has been increased considerably. Micro strip patch antennas have low fabrication cost hence can be manufactured in large quantities; they can be easily integrated with microwave integrated circuits to operate for dual and triple frequency operations [3]. However, the main disadvantage of microstrip antenna is narrow bandwidth.

Bandwidth improvement is an important need for many wireless applications such as high speed networks. To increase the bandwidth of microstrip antenna there are different techniques available in the literature. In wide band dual beam U-slot microstrip antenna by Ahmed Khios et al., low profile E-shape microstrip patch antenna by C.Chem.et al., Rectangular slot antenna with improved bandwidth by Xu- boa Sun et al., Bandwidth improvement of microstrip antenna array using dummy electromagnetic band gap (EBG) pattern feeding line by M.Gujral et al., Bandwidth enhancement of microstrip antenna by A.A.Abdelaziz. But all these shapes have less bandwidth in the operating frequency. One strategy to improve the bandwidth of microstrip antenna is to create several resonances into one antenna structure, by adding more patches.

When multiple antennas are closely placed then mutual coupling is developed between the antennas [2]. Mutual coupling is a common problem in the antenna arrays. It affects the operation of any type of antenna arrays. These mutual couplings are mainly due to the radiation interaction from closely placed antennas. There are many methods to decouple the antenna systems. Effectiveness of a given decoupling method depends on the type of the antenna array and application. In a uniplanar compact –electromagnetic band gap supersaturate (UC-EBG) is employed to reduce the mutual coupling developed in patch antenna array. However, this method is complex and occupies large space in the system.

In this paper, a four element array microstrip patch antenna array is designed. It simultaneously improves the impedance bandwidth and reduces the mutual coupling. Improved impedance bandwidth is obtained by combining E-shape and U-shape patch into one antenna structure. To reduce the mutual coupling, a vertical patch is placed between the identical antennas. This simple approach limits the surface current distribution flowing on the ground plane.

The rest of the paper is organized as follows. Design and analysis of proposed antenna is discussed in section II. In Section III presents the results of the simulated antenna and includes a discussion on the obtained results. The paper is finally concluded in section.

2. DESIGN AND ANALYSIS OF PROPOSED ANTENNA

The proposed antenna array is a combination of both U-shape and E-shape patches and designed using CST microwave studio as shown in Fig.1.It consists of a micro strip feed line and ground plane. The overall dimension is 45mm*180mm and consists of U-shape and E-shape patch antennas are used to improve the bandwidth of micro strip antennas as discussed in [5, 9, 10]. In the proposed design, E-shape patch is connected with U-shape patch into one antenna and is placed closer to another identical antenna. Both these antennas are separated by vertical patch structure to reduce mutual coupling.

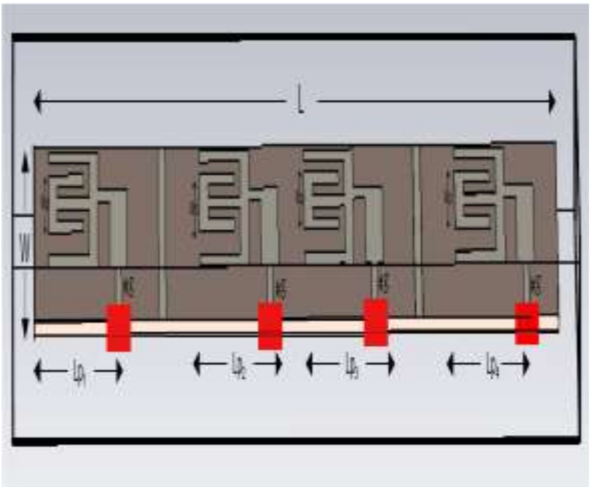

Fig (1). View of proposed antenna

There is a single layer substrate between the ground plane and the microstrip feed line. The proposed antenna design achieves wide bandwidth because of multiple resonant modes that are generated between the ground plane and microstrip feed line. The optimized dimensions of the proposed antenna along with other design parameters are in Fig 1. They are given below

L = 90 mm, W = 45 mm, w_p = 15 mm, w_{p1}= 30 mm, w_f = 20 mm, w_g = 13 mm, L_p = 10 mm, L_{p1} = 28 mm, L_{p2}=14 mm, L_f = 2 mm, L_m = 2.5 mm, L_W =3mm, g =1.05mm, ε_r =4.4.

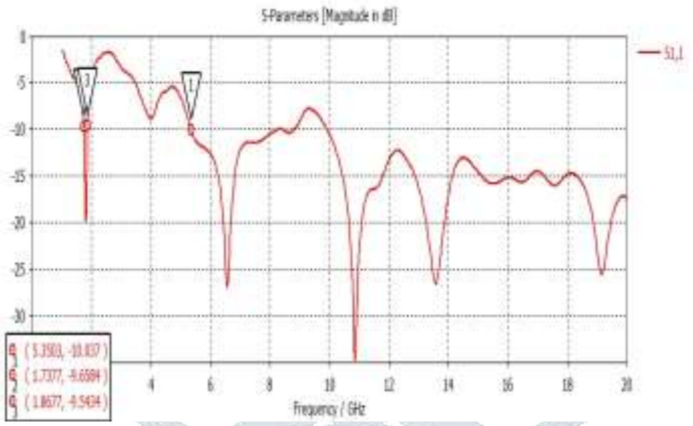

Fig (2.a) S11 of PROPOSED MODAL

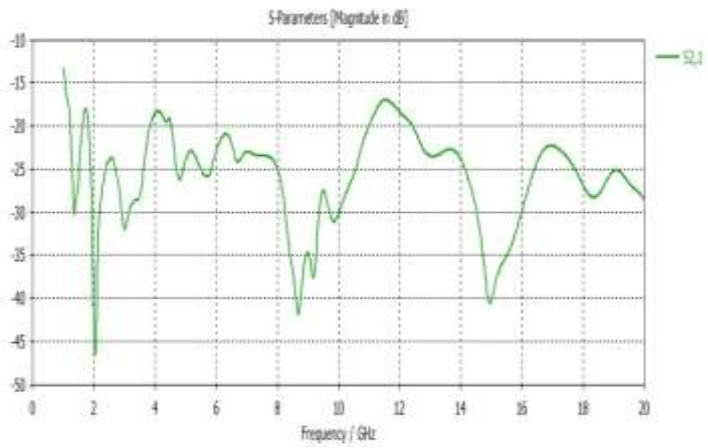

Fig (2.b) S2-1 parameters of proposed antenna

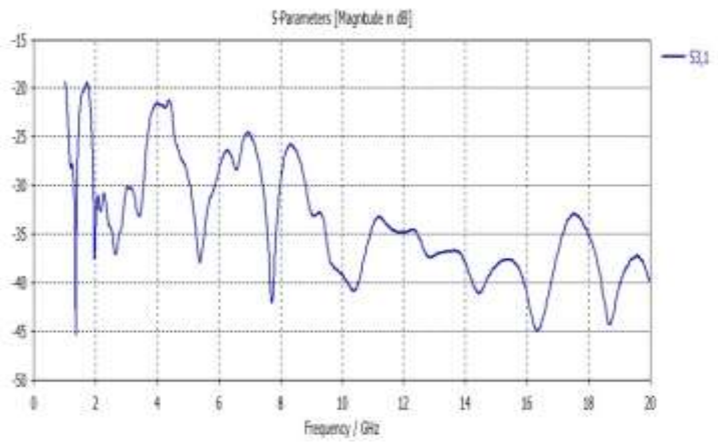

FIG (2.C):S31 PARAMETER OF PROPOSED ANTENNA

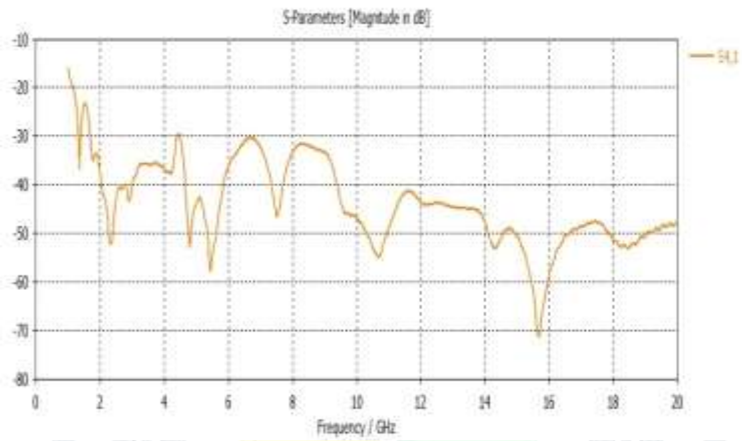

Fig (2.d) S41 parameter of proposed antenna

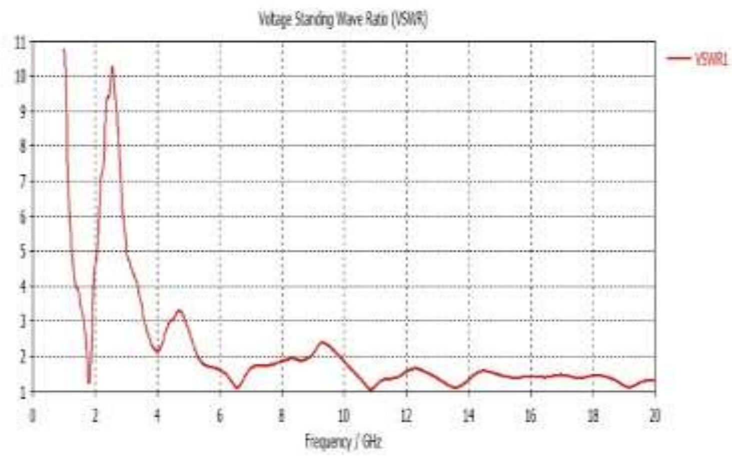

Fig (2.e): VSWR of proposed modal

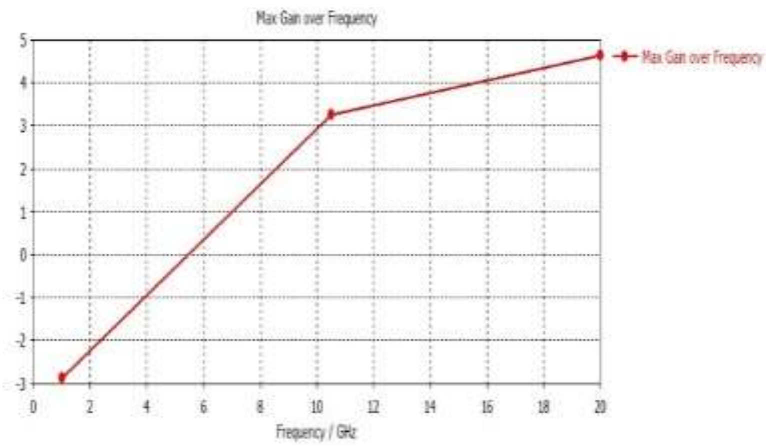

Fig (2.f): Gain vs frequency of proposed antenna

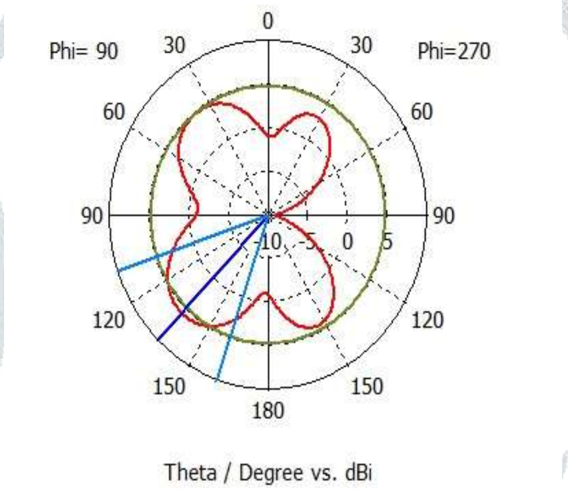

Fig2.2 Radiation pattern

There is a single layer substrate between the Ground plane and the microstrip feed line. The proposed antenna design achieves wide Bandwidth because of multiple resonant modes that are generated .between the ground plane. And microstrip feed line The optimized dimensions of the proposed antenna along with other design Parameters are given below.

The proposed four element MIMO antenna array is developed on FR4 substrate with a relative dielectric constant $\varepsilon r= 4.4$, loss tangent of 0.02 and having a fh is high frequency at -10 dB f l is low frequency at-10 dB Fig. 5 shows the gain of the proposed antenna at the resonant frequency is 1.24 dB.a the radiation pattern of the proposed f c is center frequency

$$FBW=\frac{fh-fl}{fc}\times 100$$

The limitation of VSWR for microstrip patch antenna design antenna in E-plane and H-plane respectively are shown. It is may be inferred that this antenna array has nearly an Omni-is VSWR ≤ 2. For the proposed antenna VSWR is 1.15.directional radiation characteristics. It is also observed that the Hence, the reflection coefficient frequency 7.5 GHz. At the resonant proposed antenna produces relatively stable pattern wi.

Results and Analysis

Author	Frequency(GHz)	S11(dB)	FBW*
Xu-bao[3]	2.02 to 2.88	24.13	36%

M.Gujral[4]	13 to17	26.76	22.9%
Ahmed[5]	5 to 6	18	11.3%
A.A.Abd[7]	8 to 12	20	12%
Proposed Design	5.8 to 9.2	23	45.33%

In Table I, the simulation results obtained from the proposed antenna design are compared with some of the existing designs available in the literature. It may be concluded that the proposed antenna will be a good candidate for use in practical wireless systems. The proposed antenna has more bandwidth with respect to the existing antennas. It is suitable for many wireless applications

CONCLUSION

A simple compact E-shape and U-shape combined patch antenna array for MIMO wireless applications is presented. This MIMO antenna array resonates at 7.5 GHz with an improved fractional bandwidth of 45.33% in the frequency range 5.8 GHz-9.2 GHz and with a reduced mutual coupling of 21 dB at the resonant frequency. Antenna performance in terms of return loss, gain, bandwidth, VSWR, radiation pattern and radiation efficiency are extracted for the proposed design. The radiation efficiency of the proposed antenna is 88.16%. It has improved bandwidth and reduced mutual coupling, hence making it suitable for many wireless applications including high speed data transfer networks.

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