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Usage of Shaped Stubs for Mutual Coupling Reduction in A MIMO Antenna

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Abstract: This paper discusses about the performance of a novel-shaped multi-input multi-output antenna (MIMO) which exhibits high-performance gain and low mutual coupling. The proposed design of the antenna is the introduction of radiating elements in the ground plane of the design, these radiating elements in turn help in producing high isolation between the MIMO antenna. The mentioned design of the antenna has a high diversity gain (DG>9.7) a very low mutual coupling (S21 < -60) an envelope correlation coefficient (ECC<0.07) and over the entire UWB frequencies high peak gains can be observed.
Keywords: UWB, MIMO, S-Parameters, CST, ECC

I. INTRODUCTION

In April 2002, the FCC approved ultra-wideband (UWB) that lies within 3.1 to 10.6GHz for commercial use [1]. Ultra Wideband (UWB) technology has gained much importance in the recent times because of its ability to use a very low energy level for short-range, high-bandwidth communications over the radio spectrum high data rate and its low cost of fabrication made it as a useful application in mobile and wireless communication. Therefore, in order to improve the capacity of the system, the UWB MIMO antenna has been developed for commercial systems. UWB MIMO antenna with high isolation has application in short-range high-data-rate, transmission automotive communications, and radar imaging systems [2,3]. A MIMO antenna consists of at least two radiating elements, placed at a certain distance to have high isolation between them, but the available space is very limited in the modern portable wireless front-ends. Various techniques have been proposed for UWB-MIMO antenna for diversity application [4]–[8].

The main advantage of employing MIMO antenna in UWB is its ability to increase transmission quality and to reduce multipath fading in a communication system. Certain techniques are also reported to improve isolation. Methods include using simple and fractal-based DGS [9], EBG [10], soft surface structures [11], and Metamaterial-Inspired Isolation in between the antenna elements [12].

II. PROPOSED METHODOLOGY

The proposed Planar Patch antenna was designed using Computer Simulated Technology (CST) Software. CST is used for the simulation of electromagnetic designs that comprises of various modules, we make use of CST MICROWAVE STUDIO which is used to enable the analysis of antennas, filters, couplers, planar and multi-layer structures, SI and electromagnetic compatibility (EMC) effects. The design procedure is comprised of 7 steps.

Initially, the general form of MIMO antennas results in high mutual coupling and low isolation between them. So, we modify the tree-shaped MIMO antenna to obtain S21 parameters of value less than -60dB we achieve this by modifying the ground plane to insert F-shaped stubs between the antennas.

For the design of the antenna, Flame Retardant (FR)-4 Lossy type material has dielectric constant (εr) of value 4.4, is used as the substrate as it has high mechanical strength and Electrical insulating qualities in both dry and humid conditions. The antenna dimensions of the design are 60 ×30 ×1.52mm3. The substrate is used as base material for the antenna fabrication. The patch is laid on the substrate and ground materials.

The patch is then modified to required shape of the antenna. The width of the feed line for both monopoles is chosen as 3 mm to have a line characteristic impedance of 50 ohms. Initially, a stepped cut rectangular shape UWB patch radiator was designed [13], then it is modified to triangular shape with two-step cut in the lower edge of the radiator to achieve a wide-band matching. The proposed design is somewhat similar to [14].F-Shaped stub is inserted on the ground plane for reduction of mutual coupling and to increases the isolation between the antenna elements. The design of the proposed antenna and the design parameters are shown in Figure.1 and the antenna dimensions are mentioned in Table 1.

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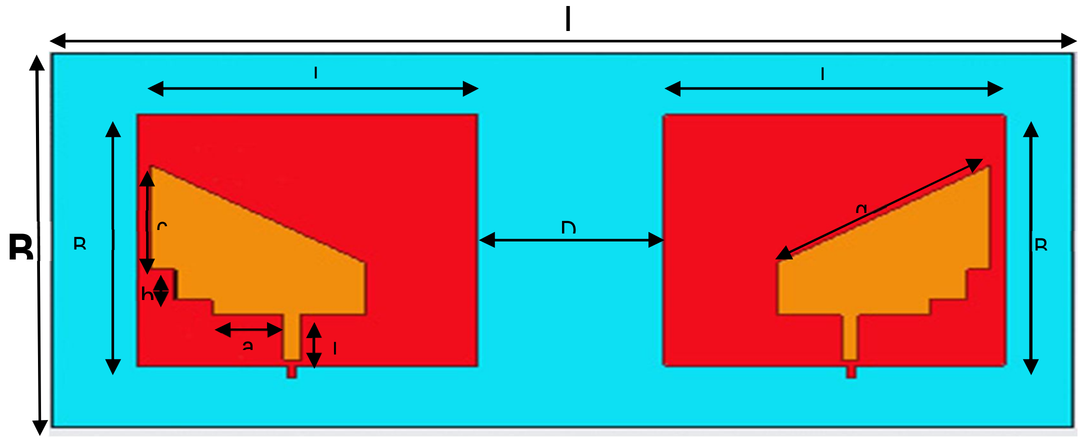

Figure 1. Design of proposed antenna.

Table 1. Parameters of proposed antenna.

Parameter	L	B	Lp	Bp	Lf	A	B	C	G	D
Dimensions (mm)	60	30	20	20	3.6	4	2.45	8.35	13.28	11

III. RESULTS DISCUSSION

A. *Return Loss*

Fig. 2 shows the simulated and measured S-Parameters for the designed UWB-MIMO antenna. The S-Parameters of the fabricated antenna (Fig. 2) is measured and results are matched well with the simulated results. The designed antenna covers 2 GHz to 10 GHz bandwidth with S11/S22 < −15 dB and S21/S12 < −60 dB. One resonance in the S11 curve is due to the main radiator and the second resonance is achieved by the introduction of the F-shaped stubs.

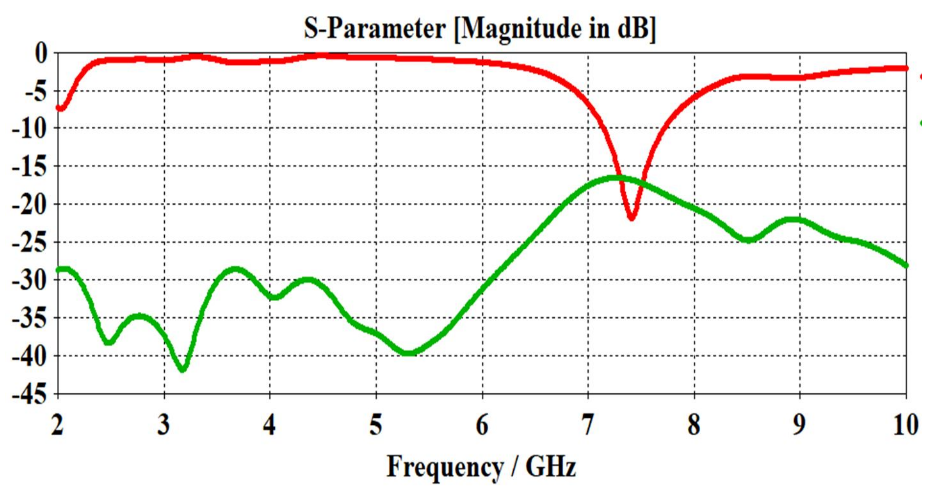

Fig. 2 S-Parameters of the proposed UWB-MIMO antenna

B. *Diversity Gain And Envelope Correlation*

To study the performance of the designed UWB-MIMO antenna, it is necessary to have low envelop correlation coefficient (ECC). ECC should have ideally zero value but practical limit for an uncorrelated MIMO antenna is ECC < 0.5. The ECC of the proposed antenna has ECC less than 0.06. Fig. 3 shows the ECC of the proposed UWB-MIMO antenna. It can be noticed from Fig. 3 that the proposed antenna has ECC < 0.07 for the entire UWB range. Another important parameter for MIMO antenna performance is its diversity gain (DG). Where ECC is the envelop correlation coefficient. Fig. 3 shows the DG with varying frequencies. It is noted that the proposed antenna has diversity gain (DG > 9.5 dB) for the entire UWB range.

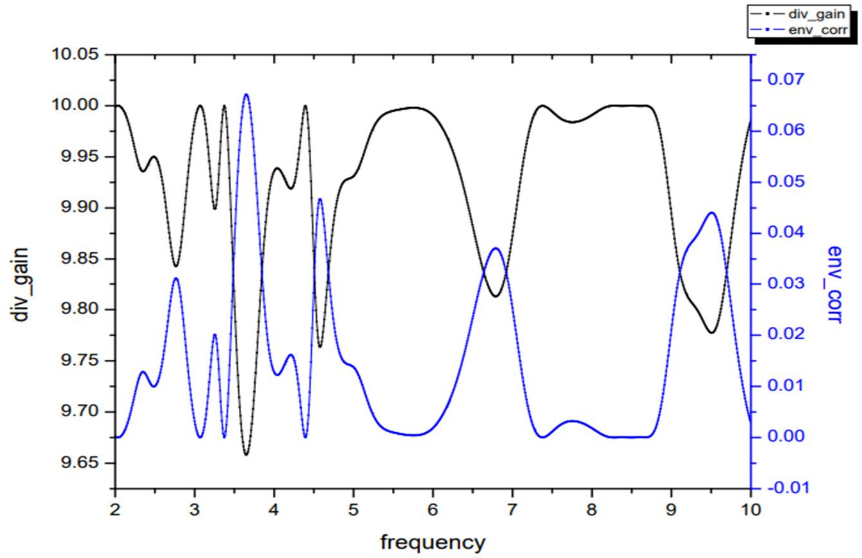

Fig. 3. ECC and Diversity Gain of the proposed antenna

C. Surface Current

A high amount of surface current is seen on the left side of the PSG arm and closest arm of the antenna element and a very low amount can be seen on the remaining antenna elements due to current coupling. Its effect can be seen on the lower frequency band on S parameters

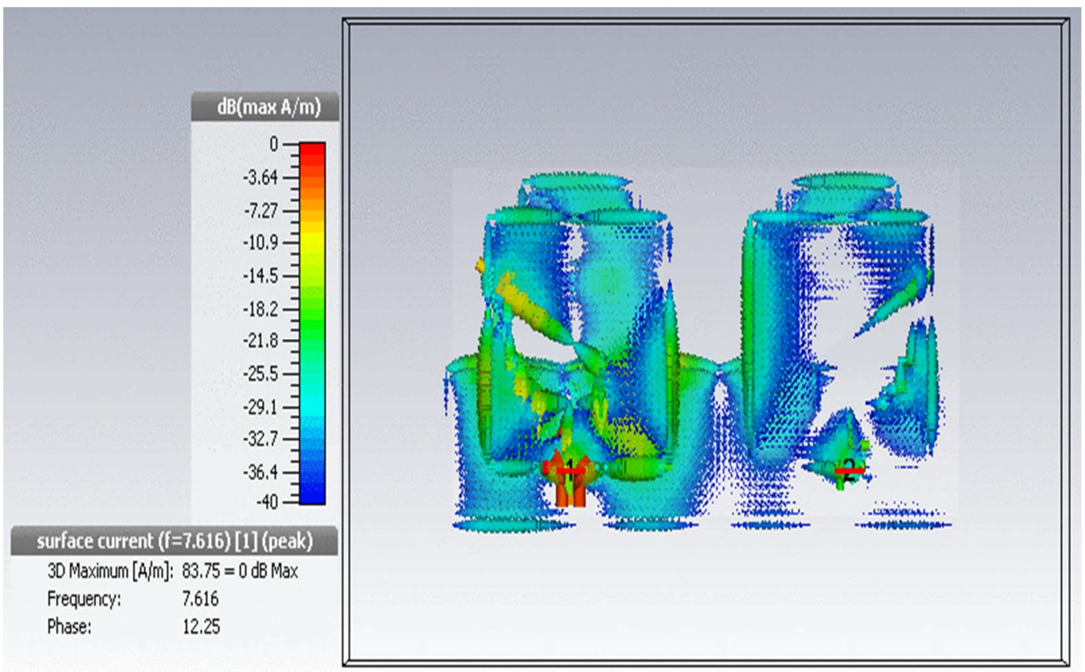

Fig. 4 Surface current distribution

IV. CONCLUSION

A compact two element MIMO antenna with common ground plane for UWB applications has been proposed in this paper. The proposed antenna has a simple structure and a compact size. High isolation between the MIMO elements is achieved by introducing F-shaped stub in the ground plane of the MIMO antenna. Simulated results for Envelop Correlation Coefficient (ECC < 0.06), Diversity gain (DG > 9.4 dB) and Multiplexing efficiency shows that the antenna is a good candidate for UWB-MIMO system.

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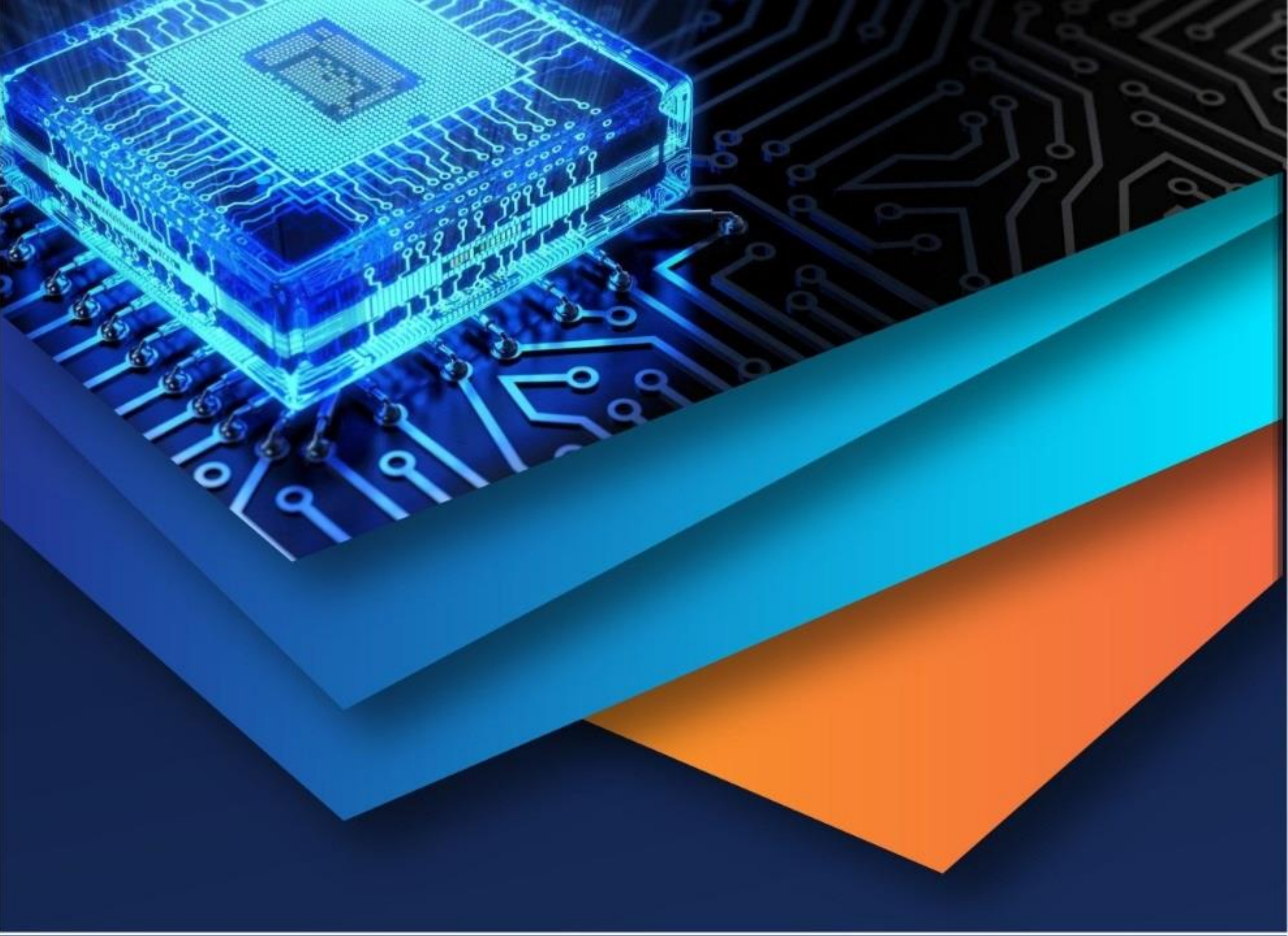

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