Mutual Coupling Reduction Using F-Shaped Stubs in MIMO Antenna

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Abstract- A compact, high performance, and novel-shaped ultra-wideband (UWB) multiple-input multiple-output (MIMO) antenna with low mutual coupling is presented in this paper. The proposed antenna consists of two radiating elements with shared ground plane having an area of 50×30 mm^2.F-shaped stubs are introduced in the shared ground plane of the proposed antenna to produce high isolation between the MIMO antenna elements. The designed MIMO antenna has very low mutual coupling of (S21 < −20 dB), high diversity gain (DG > 7.4 dB), high multiplexing efficiency (ηMux > −3.5), and high peak gain over the entire UWB frequencies. The antenna performance is studied in terms of S-Parameters, radiation properties, peak gain, diversity gain, and multiplexing efficiency. A good agreement between the simulated and measured results is observed.

Indexed Terms- MIMO antenna, diversity gain, multiplexing efficiency, microstrip patch.

I. INTRODUCTION

This band is a technology for transmitting information across a wide bandwidth (>500 MHz). This allows for the transmission of a large amount of signal energy without interfering with conventional narrow band and carrier wave transmission in the same frequency band. Regulatory limits in many countries allow for this efficient use of radio bandwidth, and enable high-data-rate personal area network (PAN) wireless connectivity, longer-range low-data-rate applications, and radar and imaging systems, coexisting transparently with existing communications systems. In radio, MIMO is a method for multiplying the capacity of a radio link using multiple transmission and receiving antennas to exploit multipath propagation. MIMO has become an essential element of wireless communication standards including IEEE 802.11n IEEE 802.11ac WiMAX, and Long-Term Evolution (LTE). More recently, MIMO has been applied to power-line communication for three-wire installations as part of the ITU G.hn standard.

At one time, in wireless the term "MIMO" referred to the use of multiple antennas at the transmitter and the receiver. In modern usage, "MIMO" specifically refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel by exploiting multipath propagation. Although the "multipath" phenomenon may be interesting, it is the use of orthogonal frequency-division multiplexing (OFDM) to encode the channels that is responsible for the increase in data capacity. MIMO is fundamentally different from smart antenna techniques developed to enhance the performance of a single data signal, such as beamforming and diversity. Isolation between the MIMO elements is created by inserting a stubs diagonally between the radiating elements. Mutual coupling of perpendicularly placed radiators has been reduced using stubs on the ground plane with a compact size antenna. High isolation is achieved in by using stubs on the ground plane Mutual coupling is reduced by introducing a rectangular stub in between the two radiators.

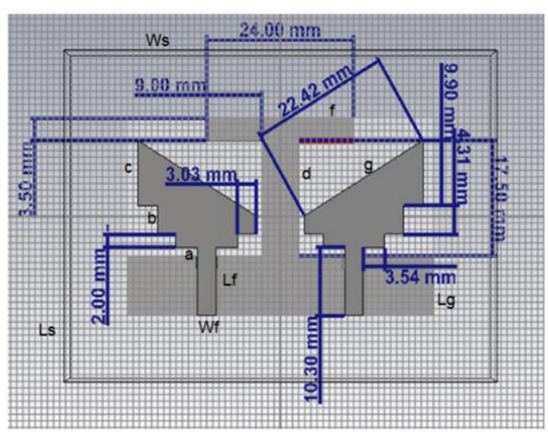

Figure 1: Top view of proposed antenna

II. ANTENNA CHARACTERIZATION

Here the UWB-MIMO antenna consists of two monopoles fed by microstrip lines and F-shaped stubs are introduced in the ground plane to produce multiple resonance and high isolation between the radiating elements.

Parameters	Dimension (mm)
a	3.54
b	4.31
c	9.99
d	17.50
f	9.00
g	22.42
Lf	10.30
Lg	9.00
Ls	30.00
Wf	3.00
Ws	50.00

Table 1: Dimensions of optimized parameters of the proposed UWB-MIMO antenna.

The radiating elements and the feed line are designed on the top of the substrate and the ground plane is designed on the bottom of the substrate. The upper patch is cut by triangular shape and place side by side to achieve wide band matching and good element spacing. then modified to triangular shape with two step cut in the lower edge of the radiator to achieve a wide-band.

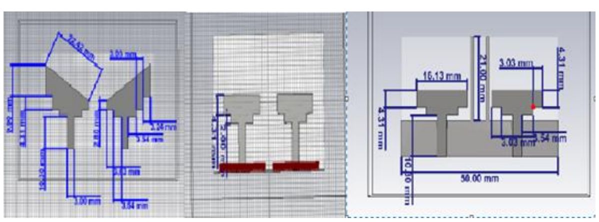

Figure 2: Geometry of the proposed UWB-MIMO antenna with modifications in ground plane.

Table 1 represents the optimized parameters of the designed UWB-MIMO Antenna. A second monopole of the same shape is placed near to it as shown in Fig. 1 having shared ground plane. Greater space for better isolation between the antenna elements is achieved by using triangular shaped mono poles to have perfect impedance matching. Fig. 2 shows the developements in the designs of the ground plane .Basically we construct the substrate with respective parameters with respective to the ground plane .we build the individual rectangular design for each to construct patch of the respective values we cut the above rectangular patches into triangular shape coming to the ground stubs with help of the rectangular or l shaped stubs and attached vertically and horizontally based on the axis and diameters 50*30 mm^2 .mutual coupling is reduced by modifying the ground plane. High isolation between the MIMO antenna elements is achieved by printing I-shaped stubs on the plane.

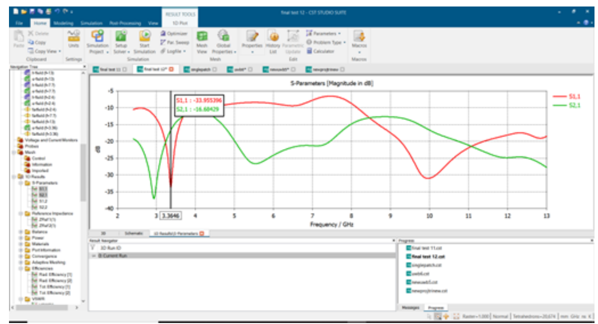

Figure 3: Simulated S-Parameters, to illustrate the effect of change in ground plane.

Antenna properties is highly effected by the position of the F-shaped stub. Fig. 3 shows that more than 20 dB of isolation is produced by inserting F-shaped stubs. Secondly, they also act as radiator to produce two resonances at 4.6 and 6.8 GHz as shown in the Fig. 3. The resonance can be further increased by introducing multiple subs at different locations

The performance of the proposed UWB-MIMO antenna is further analyzed by plotting surface current distribution with modified ground planes (introduction of different stubs) at 7.1 GHz. Surface current distribution of the proposed antenna is shown in Fig. 4. When port 1 is excited, high mutual coupling is achieved between the monopoles as current is highly coupled with other radiator as shown in F-shaped stub is placed on the ground plane to further increase the isolation between MIMO antenna elements. that by introduction of F-shaped stubs, very less current is coupled with the other radiator and hence greater isolation between the antennas is achieved.

Literature	Size (mm^2)	Bandwidth (GHz)	Isolation (dB)	ECC	Diversity Gain (dB)
Ref. [1]	37×45	3.1-5	>15	<0.5	NA
Ref. [2]	32×32	3.1-10.6	>15	0.04	NA
Ref. [4]	26×40	2.1-10.6	>15	0.20	NA
Ref. [10]	25×40	3-10.6	>15	NA	NA
Proposed work	50×30	2.5-14.5	>20	<0.04	>7.4

Table 2: Performance comparison with previously published work.

III. RESULTS AND DISCUSSIONS

The antenna is designed on commercially available substrate of FR-4 having dielectric constant $\varepsilon_r = 4.4$ and height hs = 1.6 mm.

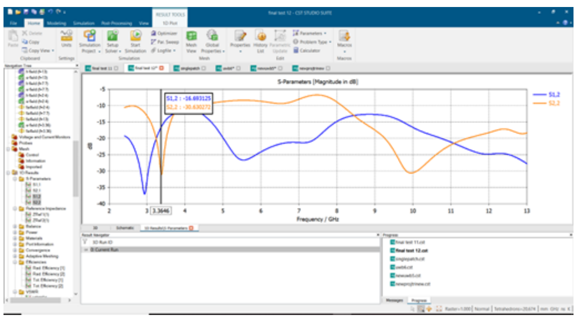

Figure 5: S-Parameters of the designed UWB-MIMO antenna.

A. RETURN LOSS

It shows the simulated and measured S-Parameters for the designed UWB-MIMO antenna. The S-Parameters of the fabricated antenna (Fig. 5) is measured using Agilent Network Analyzer (VNA) in open air conditions and the results matched well with the simulated results. The designed antenna covers 2.5 GHz to 14.5 GHz bandwidth with $S11/S22 < -10$ dB and $S21/S12 < -20$ 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.

B. RADIATION PATTERN AND GAIN

The measured and simulated results are compared in Fig. 6. A good agreement between simulated and measured results has been observed. For pattern measurement, the proposed antenna is fixed on turnable. The fabricated antenna was tested in Anechoic Chamber to measure its radiation properties. It was observed that θ-component was dominant in yz-plane while $\emptyset$-component was dominant in xz-plane. $\emptyset$-component in xz-plane as well as in yz-plane has omnidirectional pattern at lower frequencies while this pattern slightly change its shape for higher frequencies in both planes. The θ-component of the electric field in xz-plane as well as in yz-plane has toroidal shape at lower frequencies while the shape slightly changes at higher frequencies. Simulated peak gain of the proposed antenna is shown in Fig. 7. Peak gain of the proposed antenna varies from 0.3 dB to 4.3 dB, changing linearly for the entire range of UWB.

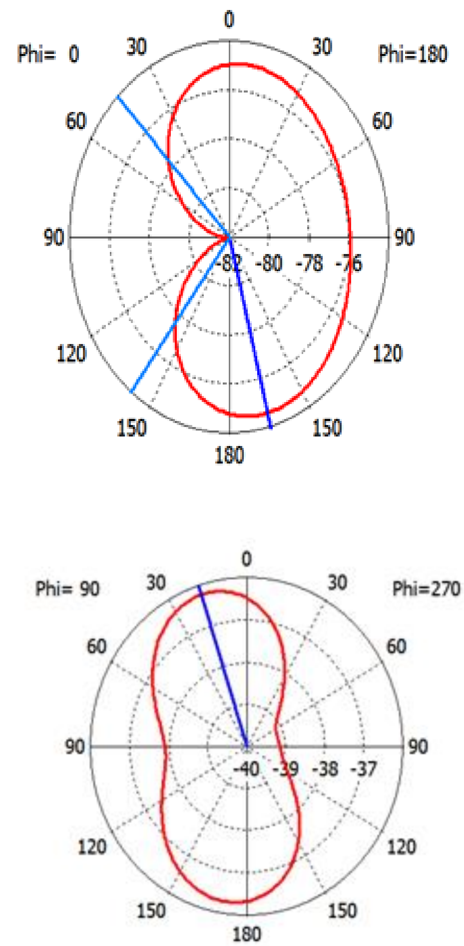

Figure 6: Simulated and measured radiation pattern at 4.6 and 6.8 GHz.

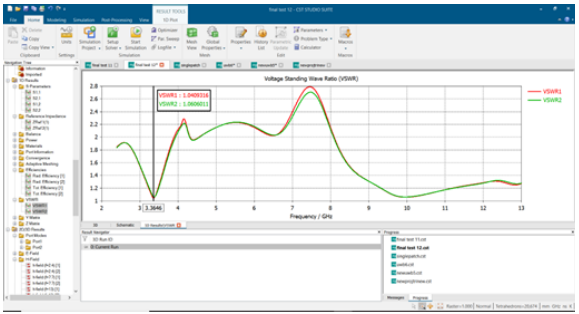

Figure 7: VSWR

IV. CONCLUSION

A compact two element MIMO antenna with shared ground plane has been proposed in this paper. The proposed antenna has simple structure and compact size of 50×30 mm^2. High isolation between the MIMO elements is achieved by introducing F-shaped stub in the ground plane of the MIMO antenna. Diversity gain (DG > 7.4 dB) and Multiplexing efficiency shows that the antenna is good candidate for UWB-MIMO system.

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