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COMPACT ELLIPTICAL SHAPED UWB MIMO ANTENNA WITH IMPROVED ISOLATION

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Abstract - This paper presents a compact, Elliptical shaped Multiple-Input-Multiple-output (MIMO) antenna with high isolation used for all Ultra-Wide Band (UWB) applications. The proposed antenna operates in 3.1GHz-13.5GHz with impedance bandwidth of 10.4GHz which includes the unlicensed band 3.1GHz-10.6GHz approved by Federal Communications Commission (FCC) in 2002.This antenna is designed on a FR-4 substrate having dimensions 19mm×32mm×1.6mm.This antenna uses partial ground plane, with two parallel parasitic elements on the ground plane for isolation improvement and achieves peak gain of 4dB at 9 GHz and highest radiation efficiency of 96.70% at 3.5GHz. The antenna characteristics such as the S- parameters, radiation efficiency and peak gain are observed using HFSS. Furthermore the performance of MIMO antenna such as Envelope Correlation Coefficient (ECC) is studied. This antenna possesses mutual coupling less than -25dB over the entire operating band.

Keywords - MIMO, UWB, FCC, ECC.

I. INTRODUCTION

In today's wireless communications, the UWB applications became popular due to the merits like low power consumption, high data rate, and high performance in multi- path channels. The FCC allocated 7,500MHz of spectrum for unlicensed use of UWB devices with a very low radiated power level of less than -41.3dBm/MHz in the 3.1GHz to 10.6GHz frequency band in 2002 [1]. Various Diversity and mutual coupling reduction techniques like Space, Polarization, Pattern diversity, Parasitic approach, Neutralization lines, Slot/ Slit etching, Meta material approach, Coupling/ Decoupling networks are studied [2].

Electromagnetic band gap structures are periodic featured to suppress surface waves and reduce the effect of mutual coupling and improve the radiation pattern and gain of antenna. By introducing paired slits in ground plane of equal length disturbs and blocks the current to propagate from one antenna element to other element and provides high isolation of more than 20dB is achieved [3]. L-shaped slots are etched on the triangular radiating patch to enhance impedance bandwidth with defected ground and tree-like structure to enhance wideband isolation [4]. Stub of T- Shaped is attached to the rectangular patch and placed perpendicular to each other with narrow slot in the ground plane to enhance isolation [5]. Two monopole antennas with vertical slot on T-shaped ground stub provides better matching and good isolation between two ports[6]. T-shaped slot etched on the pentagonal top plane radiator which is fed by two perpendicular tapered Microstrip lines and a metal branch extended on ground plane reduces the mutual coupling between two ports and increases isolation [7]. The antenna elements with half-circular conductors on top plane and inverted T- shaped common ground with rectangular slots are used to reduce mutual coupling between antenna elements [8].

II. ANTENNA DESIGN AND CONFIGURATIONS

A. Antenna Design

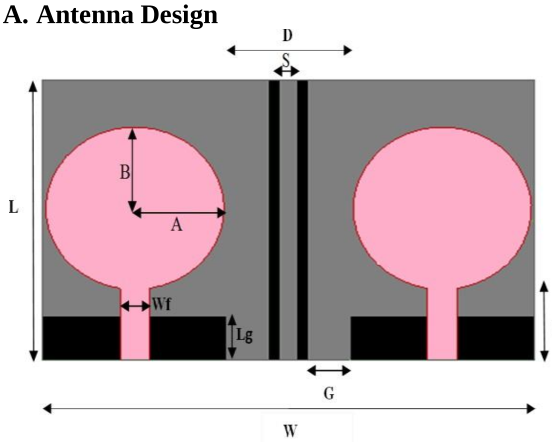

Fig. 1.Geometry of Proposed Antenna

Fig. 1 shows the structure and dimensions of the proposed elliptical shaped antennas on the low cost FR-4 dielectric substrate with relative permittivity of 4.4, thickness of 1.6 mm and loss tangent of 0.002. The size of the antenna is 19mmx32mm = 608mm^2 or 0.19λ0 x 0.32λ0 where λ0 is the free space wavelength. Initially an elliptical shaped radiating element is considered with major axis of 5.8 mm and minor axis 5.51mm and is excited with 50Ω microstrip feed line of length 7.39mm and width 1.9mm. Partial ground of 3mm with ground stub acting as reflector increases the isolation and thereby reduces the effect of mutual coupling. The ground stub is then slotted with vertical strip making the stub into two parallel parasitic elements. Two radiating elements are separated with spacing of 8mm.The size of the radiating element should be large enough, employing large current path to attain lower cut-off frequency of UWB i.e., 3.1GHz

Parameters	L	W	Lg	Lf	Wf
Unit(mm)	19	32	3	7.39	1.9
Parameters	A	B	D	S	G
Unit(mm)	5.8	5.51	8	1.1	2.7

Table 1 : Design Parameters of the Proposed Antenna

B. Decoupling Structure

In portable devices space is one of the major constraint and performance of MIMO antenna reduces due to strong mutual coupling. The main challenge is to reduce the mutual coupling using a decoupling structure while maintaining the antenna with compact size. In this design two parallel strips on the ground plane acts as strong decoupling structure. Firstly a ground stub is placed which provides isolation < -20dB, then the ground stub is slotted with vertical strip making it into two parallel strips resulting with isolation <-25dB.

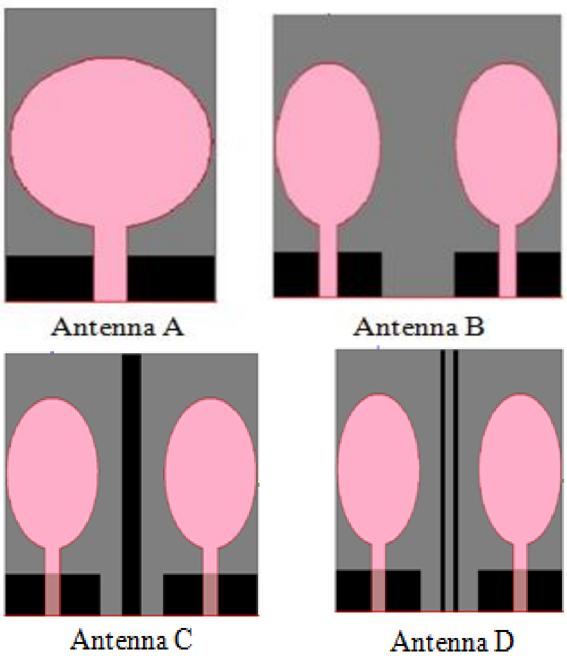

Fig.2. Geometry Evolution of the Proposed Design

Fig.2 shows the evolution steps of proposed design. Antenna B represents the combination of two UWB antennas with rectangular ground plane and 8mm separation between them, resulting in overall size of 19mmx32mm. In antenna B strong mutual coupling arises between radiating elements due to surface currents in the ground plane and results in poor isolation. In antenna C a rectangular stub is attached to the ground due to which distribution of surface current on ground plane changes leading to improvement in isolation i.e.,S12/S21<-20dB. The ground stub is slotted vertically and made in to two parallel strips in antenna D to enhance isolation i.e., S12/S21 <-25dB. By converting stub in to two parallel strips isolation is enhanced by -5 dB in the entire operating range is shown in Fig.3.

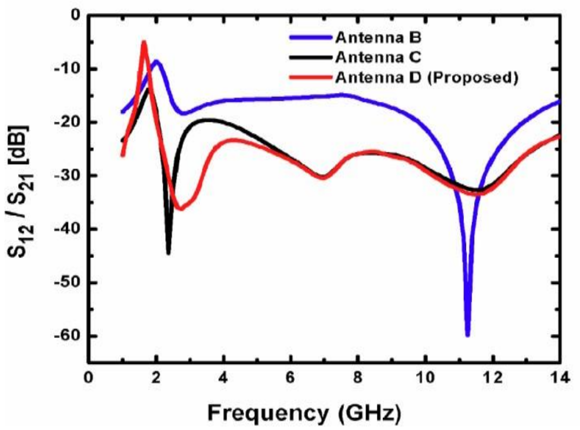

Fig.3. Simulated S-Parameters Against Frequency

C. Effect of Distance (D) and Slot (S) on S12 Parameters

The effect of distance (D) between the two elliptical radiating elements are studied for final optimization of the UWB-MIMO antenna. Fig.4 shows the effect of distance (D) between the radiators on the simulated S12 of the proposed UWB MIMO antenna. It is observed from Fig.4 that the distance (D) between the radiators mainly provides good isolation for the distance(D)=8mm.

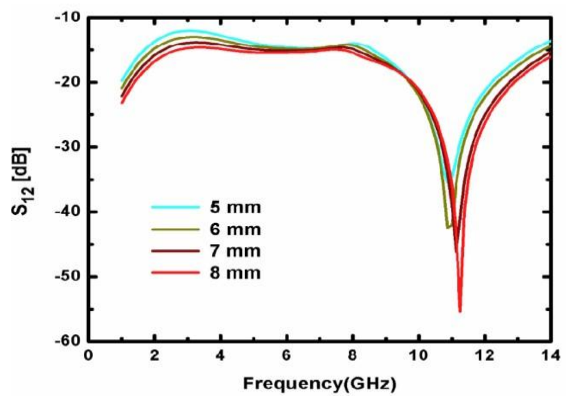

Fig.4. Simulated S-Parameters Against Frequency for Various Values of D

Initially a stub is placed on the ground plane which provides isolation <-20dB in the entire operating range. The ground stub is further slotted vertically making the stub into two parallel parasitic elements of width 0.75 mm which improves isolation and results in S12/S21<-25dB. Fig.5 shows the effect of slot (S) on the simulated S12 of the proposed UWB-MIMO antenna. It is observed from Fig.5 that the slot width (S) of 1.1 mm mainly provides good isolation.

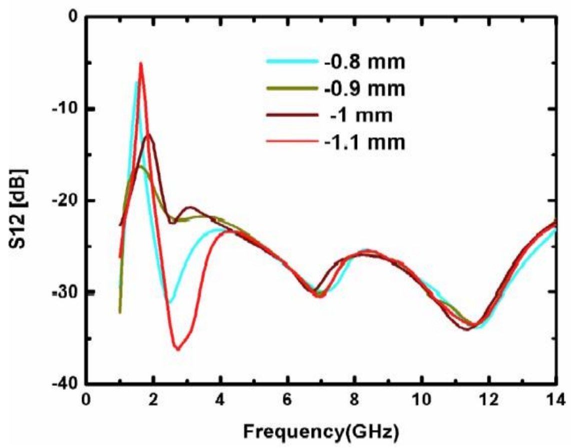

Fig.5. Simulated S-Parameters Against Frequency for Various Values of S

III. RESULTS AND DISCUSSION

S-Parameters: The simulated results of S11 and S12 are shown in Fig.6.The proposed MIMO antenna covers from 3.1-13.5GHz with an impedance bandwidth of 10.4GHz. The proposed MIMO antenna provides good isolation i.e., <-25dB.Table 2 lists the performance comparison of proposed antenna with existing MIMO antennas.

Reference #	Size (mm x mm)	Operating bands (GHz)	Isolation (dB)
4	35x40	3.1-10.6	-16
5	32x32	2.9-12	-15
6	22x36	3.1-11	-15
7	40x40	3-11	-16
8	21x38	3.1-10.6	-15
Proposed	32x19	3.1-13.5	-25

Table 2: Performance Comparison of Proposed Antenna With Other Existing MIMO Antennas.

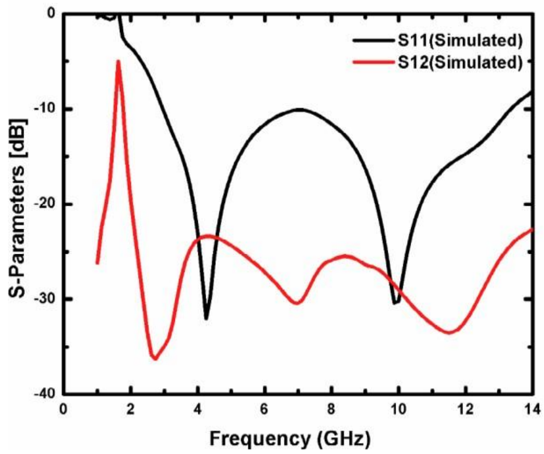

Fig.6. Simulated Results of S-Parameters for the Proposed MIMO Antenna.

The proposed MIMO antenna provides high radiation efficiency i.e.,> 93% and peak gain > 4dB in the entire operating range as shown in Fig.7.

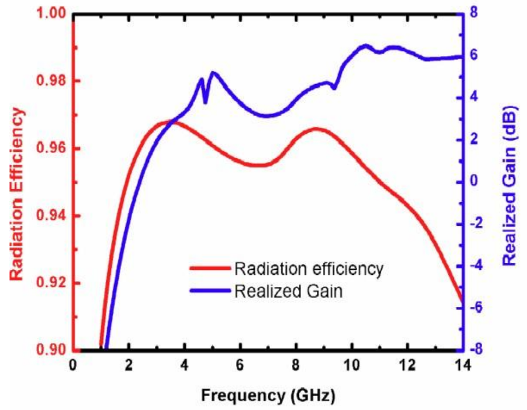

Fig.7. Efficiency and Gain for the Proposed MIMO Antenna.

The proposed UWB antenna is yielding a maximum peak gain of 4dB at 9 GHz as shown in Fig. 8

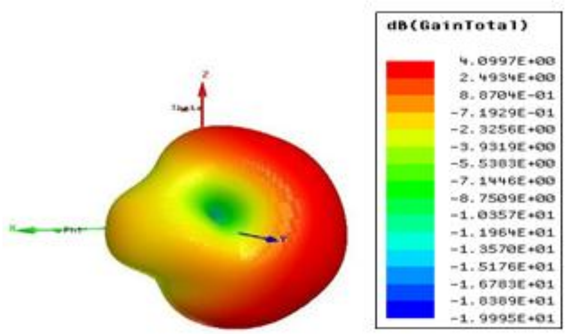

Fig.8. 3-D radiation pattern at 9 GHz.

The performance of proposed MIMO antenna is evaluated using the parameters Envelope Correlation Coefficient (ECC). The ECC value gives the coupling between antenna elements and it is useful to estimate the MIMO antenna performance and also similarities between the radiation patterns. Fig.8. depicts the simulated values of ECC.

$$ECC = \frac{\left|S_{11}^* S_{12} + S_{21}^* S_{22}\right|^2}{\left(1 - |S_{11}|^2 - |S_{21}|^2\right)\left(1 - |S_{22}|^2 - |S_{12}|^2\right)}.$$

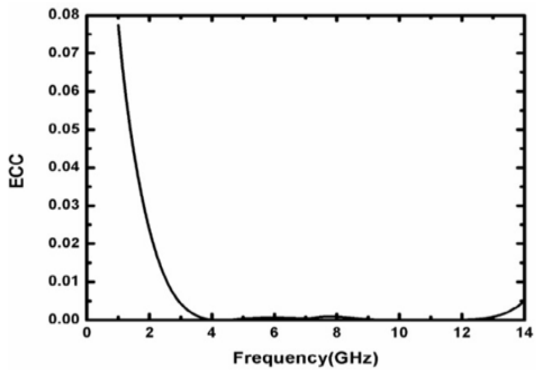

Fig.8.ECC for the Proposed MIMO Antenna.

IV. CONCLUSION

UWB-MIMO antenna with high improvement in isolation is achieved. The proposed MIMO antenna is operating between 3.1GHz-13.5GHz and is designed on a FR-4 substrate with dielectric constant 4.4, loss tangent 0.02 and fed with 50Ω microstrip line. Simulated results of S11, S12, Radiation efficiency, Peak gain, ECC are observed. The proposed UWB-MIMO antenna find its applications in entire ultra wide band and Ku band.

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