



COMPACT UWB MIMO SLOT ANTENNA WITH DEFECTED GROUND STRUCTURE

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ABSTRACT

A compact ultra wideband (UWB) multiple-input multiple-output (MIMO) slot antenna having a size of 22 x 34 mm² is proposed for portable device applications. The proposed MIMO antenna consists of two symmetric UWB slot antennas with microstrip-fed placed on the one side of dielectric substrate. To enhance the isolation between the antenna elements, two rectangular slots along with a ground stub are etched on the ground plane, which is on the other side of dielectric substrate. The proposed antenna exhibits a good 2:1 VSWR impedance bandwidth over the entire UWB band from 3.1-10.6 GHz with low mutual coupling less than -20dB, peak gain of 4.3 dBi and efficiency of more than 80%. The measured results are in good agreement with the simulation results and results show that the proposed antenna is good candidate for portable UWB applications.

Keywords : compact, defected ground structure (DGS), mutual coupling, multiple-input-multiple-output (MIMO) antenna, ultra wideband (UWB).

1. INTRODUCTION

Ultra wideband (UWB) technology has become the rapidly growing technology because of its promising advantages, such as high data rate, low cost, and operating at low power levels [1]. Like other wireless communication systems, the UWB systems suffer from multipath fading which will deteriorate the performance of UWB system. Multiple-input multiple-output (MIMO) is an efficient technology has been adopted to improve the channel capacity and mitigating the multipath fading as well in UWB systems [2]. However, installing multiple antenna elements on limited space in portable devices will cause mutual coupling problem and significantly degrade the diversity performance. And also, it is very difficult to have low mutual coupling within the ultra wideband range. Therefore, the design of compact UWB MIMO antenna system with high port isolation (or low mutual coupling) between antenna elements is challenging topic.

Several decoupling methods were proposed in the literature to enhance the isolation between the radiating elements in UWB MIMO system [2-4]. Use of orthogonal feeding structure to get high isolation⁵, adopting defected ground structure (DGS) to reduce the surface wave [6-8], adding protruded ground stubs as reflective element [9], tree-like structures, and introducing a neutralization line

[10-12]. All of the decoupling structures can provide the mutual coupling [13-15] to -15 dB or less.

In this paper, a compact two-port microstrip-fed UWB MIMO antenna is proposed for portable device applications. The proposed antenna has a very compact size of 26 X 34 X 1.6 mm³. To improve the isolation between the two radiating elements and enhance the impedance bandwidth, a defected ground structure with ground stub and two slots are used. The antenna provides larger impedance bandwidths from 2.5-10.7 GHz. The simulated and measured results show that the proposed antenna MIMO is well suitable for portable UWB systems.

2. ANTENNA DESIGN AND GEOMETRY

Figure-1 shows the geometry of the proposed compact UWB MIMO antenna. It is printed on a FR4-epoxy dielectric substrate with a overall size of L x M= 26 x 34 mm², thickness of 0.8 mm, relative dielectric constant (ϵ_r) of 4.4, and a loss tangent ($\tan\delta$) of 0.02. The top layer of proposed antenna consists of two 50-ohm microstrip lines with U-shaped radiating elements and bottom layer is a defected ground structure with a long stub and two rectangular slots. To improve the impedance matching characteristic and reduce the mutual coupling, a long ground stub and two rectangular slots are etched on the ground plane.

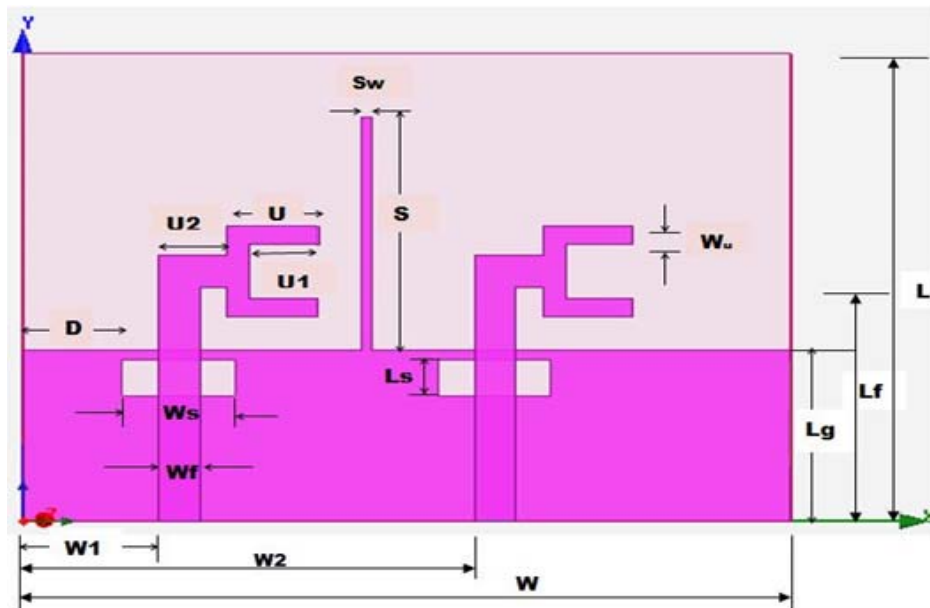


Figure-1. Geometry of proposed antenna.

The dimensions for the proposed compact UWB MIMO antenna are listed in Table-1 and used to fabricate the prototype as shown in Figure-5.

Table-1. Dimensions of proposed Antenna (in mm).

S _w	S	W _u	U	U1	L	L _s	U2	L _f	L _g	D	W _s	W _f	W1	W2	W
0.5	13	1	4	3	26	2	3	13	9.5	4.4	5	1.8	6	20	34

3. RESULTS AND DISCUSSIONS

The EM simulation tool Ansoft HFSS is used to study and optimize the parameters of the proposed MIMO antenna, in terms of impedance bandwidth, mutual coupling between the antenna elements, radiation patterns, and peak gains.

A. Effects of long ground stub and two slots

In the proposed MIMO antenna shown in Figure-1, a long ground stub and two symmetrical rectangular slots are placed in between the two U-shaped radiating patch elements. Computer simulation using Ansoft HFSS is used to study the effects of ground stub on antenna performance. The S-parameters of the antenna, such as the simulated S11 and S12 with and without stub are also shown in Figure-2 (a) and (b) to study the effects of long stub.

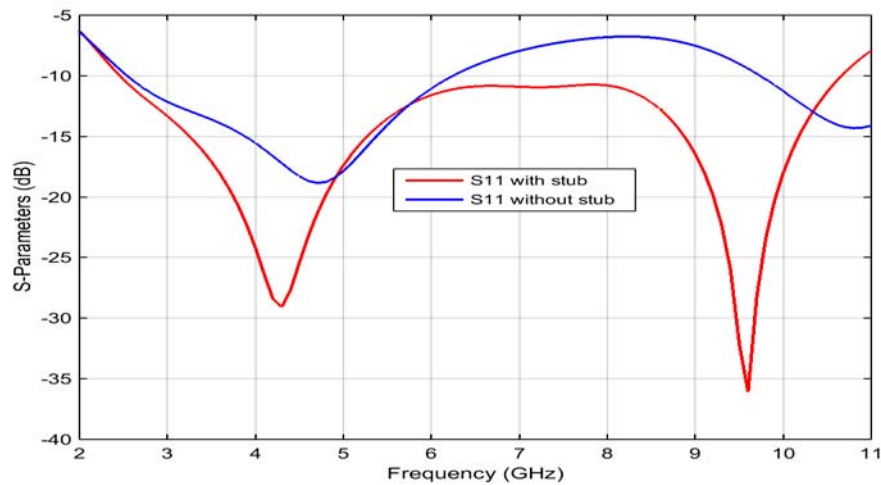


Figure-2(a). S11 with and without long ground stub.

As shown in Figure-2 (a), it can be observed that when ground stub is used, the antenna resonates at about 4.3 GHz and 9.6 GHz frequencies. The resonance at 4.3 GHz moves towards lower cut-off frequency band from 4.3 GHz to about 2.5 GHz. Similarly, the strong resonance

at 9.6 GHz shifts towards the higher cut-off frequency band from 9.6 GHz to 10.7 GHz. So, a ground stub along with two rectangular slots resulting in a high impedance bandwidth of 2.5 GHz to 10.7 GHz.

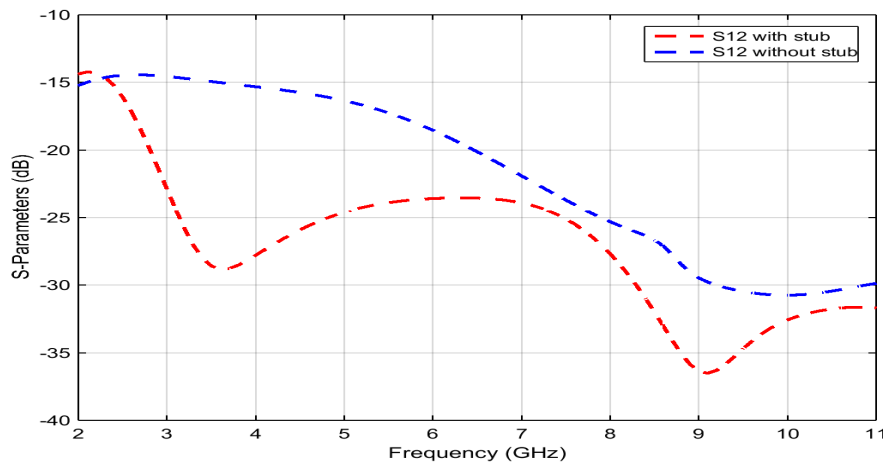


Figure-2 (b). S12 with and without long ground stub.

In general mutual coupling S12 less than -15dB is desirable for good isolation between antenna elements. From the Figure-2 (b) it can be seen that, the mutual coupling S12 with and without ground stub is less than -20 dB and -15 dB respectively, in the entire UWB band. Thus, proposed MIMO antenna with ground stub can work effectively in the frequency band from 2.5 to 10.7 GHz with good isolation of less than -20 dB.

To study the performance of MIMO antenna, current distribution is also used. The simulated current distributions of the proposed antenna with and without

ground stub at 4.3 GHz and 9.6 GHz respectively, are shown in Figure-3. Figure-3 (a) and (c) indicate that, without using ground stub, when port 1 is excited and port 2 is terminated with 50-ohm load, currents are coupled from the radiating element port 1 to radiating element port 2. Hence, mutual coupling between the antenna elements increased. With using ground stub, when port 1 is excited and port 2 is terminated with 50-ohm load, significant amounts of currents are coupled to the long stub which absorbs radiation as shown in the Figure-3 (b) and (d).

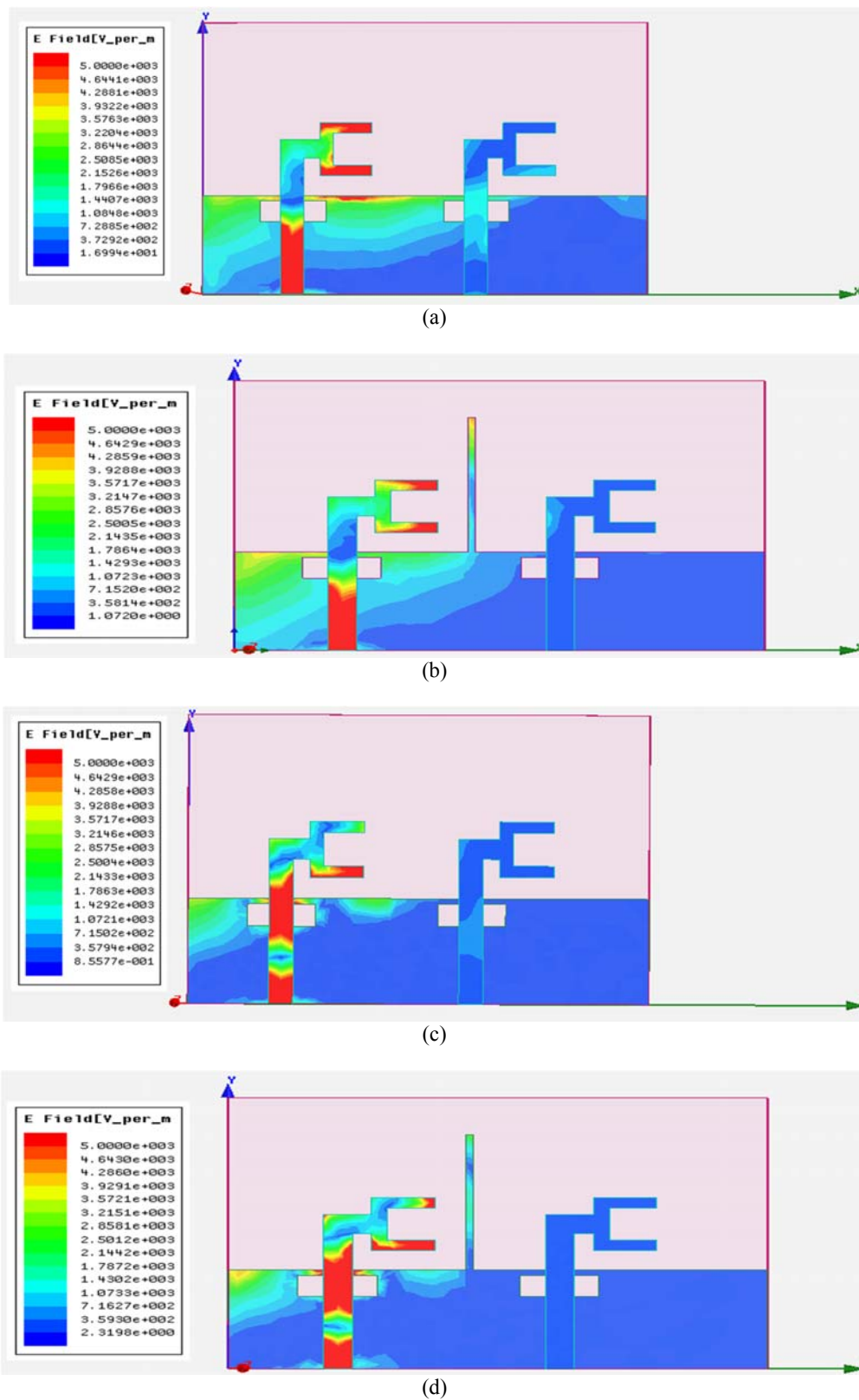


Figure-3. Current distributions at 4.3 GHz: (a) Port 1 excited without ground stub, (b) Port 1 excited with ground stub. Current distributions at 9.6 GHz: (c) Port 1 excited without ground stub, (d) Port 1 excited with ground stub.



Without ground stub, when port 2 is excited and port 1 is terminated with 50-ohm load, Figure-4 (a) and (b) show that currents are coupled to the radiating element of port 1 and flow to the port 2. Thus, mutual coupling between the radiating elements is increased. Figure-4 (b)

and (d) indicates that, when port 2 is excited and port 1 is terminated with 50-ohm load, significant amounts of currents are coupled to the long stub which radiate the power. Hence, mutual coupling between the antenna elements significantly reduced.

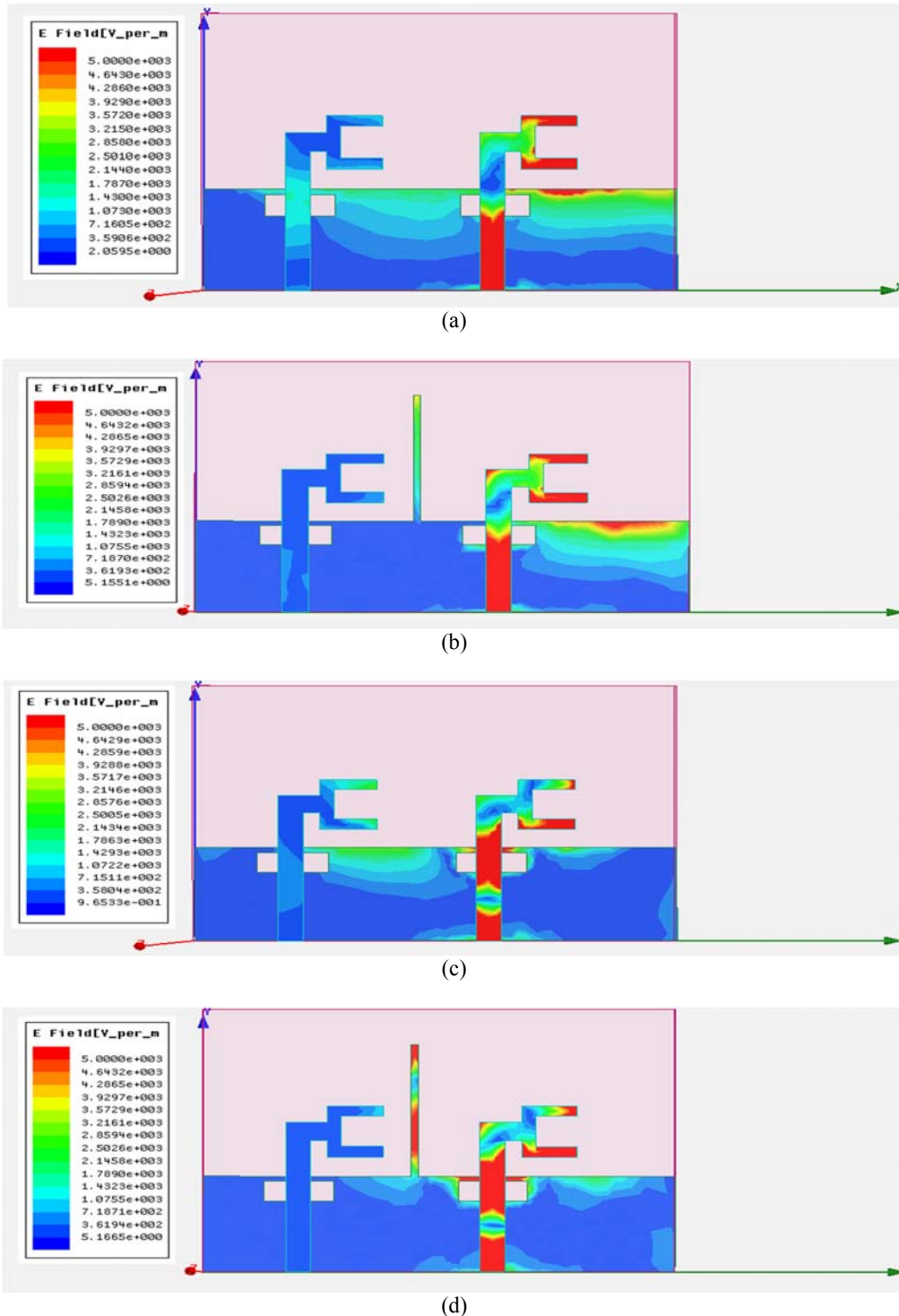


Figure-4. Current distributions at 4.3 GHz: (a) Port 2 excited with no ground stub, (b) Port 2 excited with ground stub. Current distributions at 9.6 GHz: (c) Port 2 excited with no ground stub, (d) Port 2 excited with ground stub.



The fabricated design and measured S11 and S12 parameters of the proposed antenna are shown in Figure-5 (a), (b) and (c). Figure-5 (b) indicates that measured S11 of antenna has a impedance bandwidth from 3.1-12 GHz for $S_{11} < -10\text{dB}$ and mutual coupling S12 between port 1

and port 2 is around -20dB is shown in Figure-5 (c). As from the Figure-5 (b) and (c), there is slight variation between the measured results and simulated results due to the fabrication tolerances.

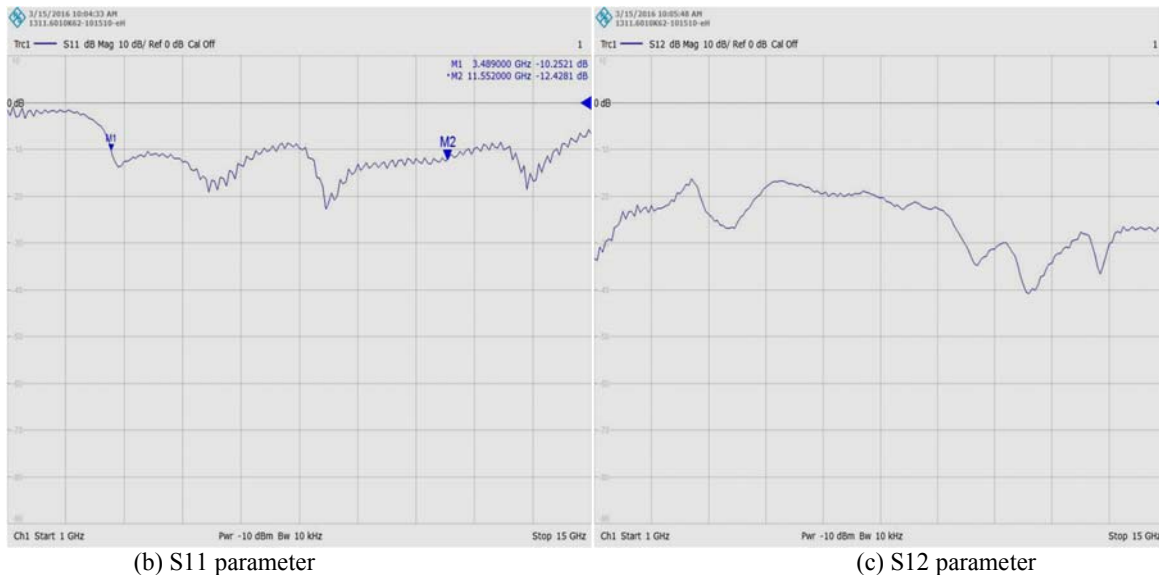
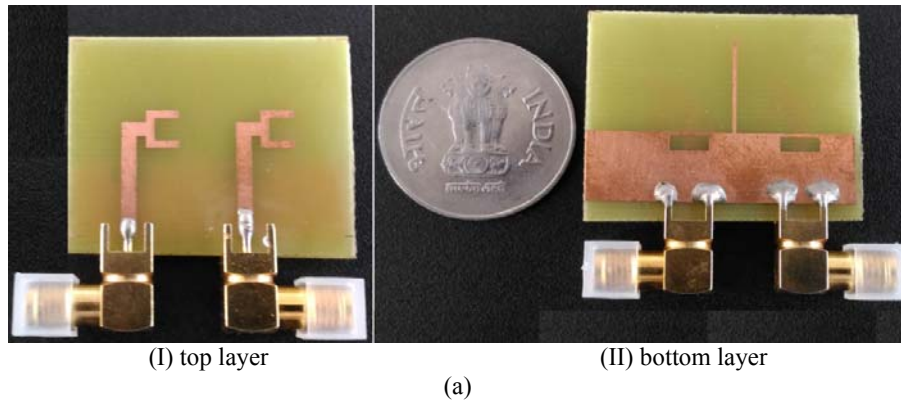


Figure-5. (a) Prototype (b) Measured S11-parameter and (c) Measured S12-parameter.

Figure-6 shows the 3D-radiation patterns of the proposed MIMO antenna resonating at 4.3 and 9.6 GHz, respectively. It can be observed that the radiation patterns are complementary to each other when excited by port 1

and port 2. So, the proposed MIMO antenna provides pattern diversity to mitigate the effects of multipath fading in UWB systems.

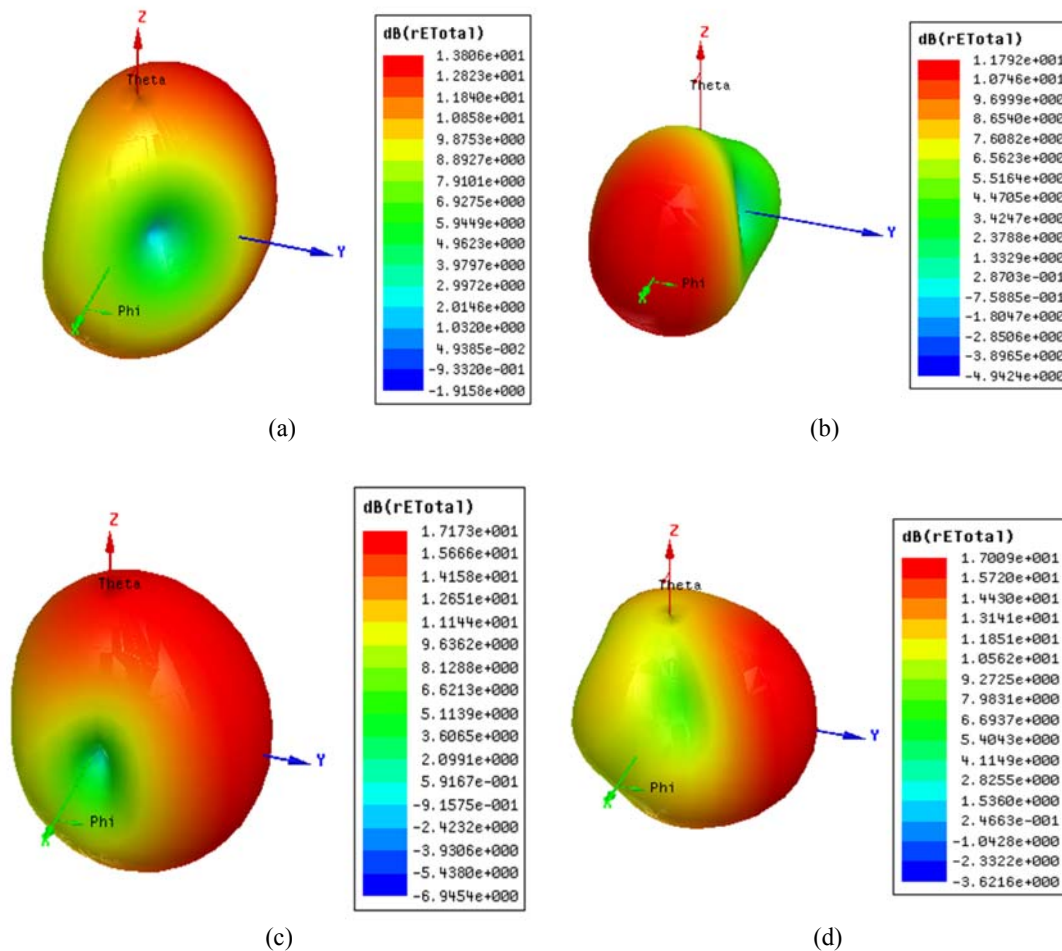


Figure-6. 3D-radiation patterns at 4.3 GHz: (a) port 1 excited, (b) port 2 excited. 3D-radiation patterns at 9.6 GHz: (c) port 1 excited, (d) port 2 excited.

The peak gain plot of the proposed antenna is shown in Figure-7(a). It indicates that the peak gain is ranging from 1.2 to 4.3 dBi in the frequency band from 2.5 to 10.7 GHz. Figure-7 (b) indicates that the antenna has

efficiency of more than 80% in the entire UWB band. From the Figure-7 (c) and (d), it can be seen that the antenna has a VSWR of less than 2 in the entire frequency band of operation.

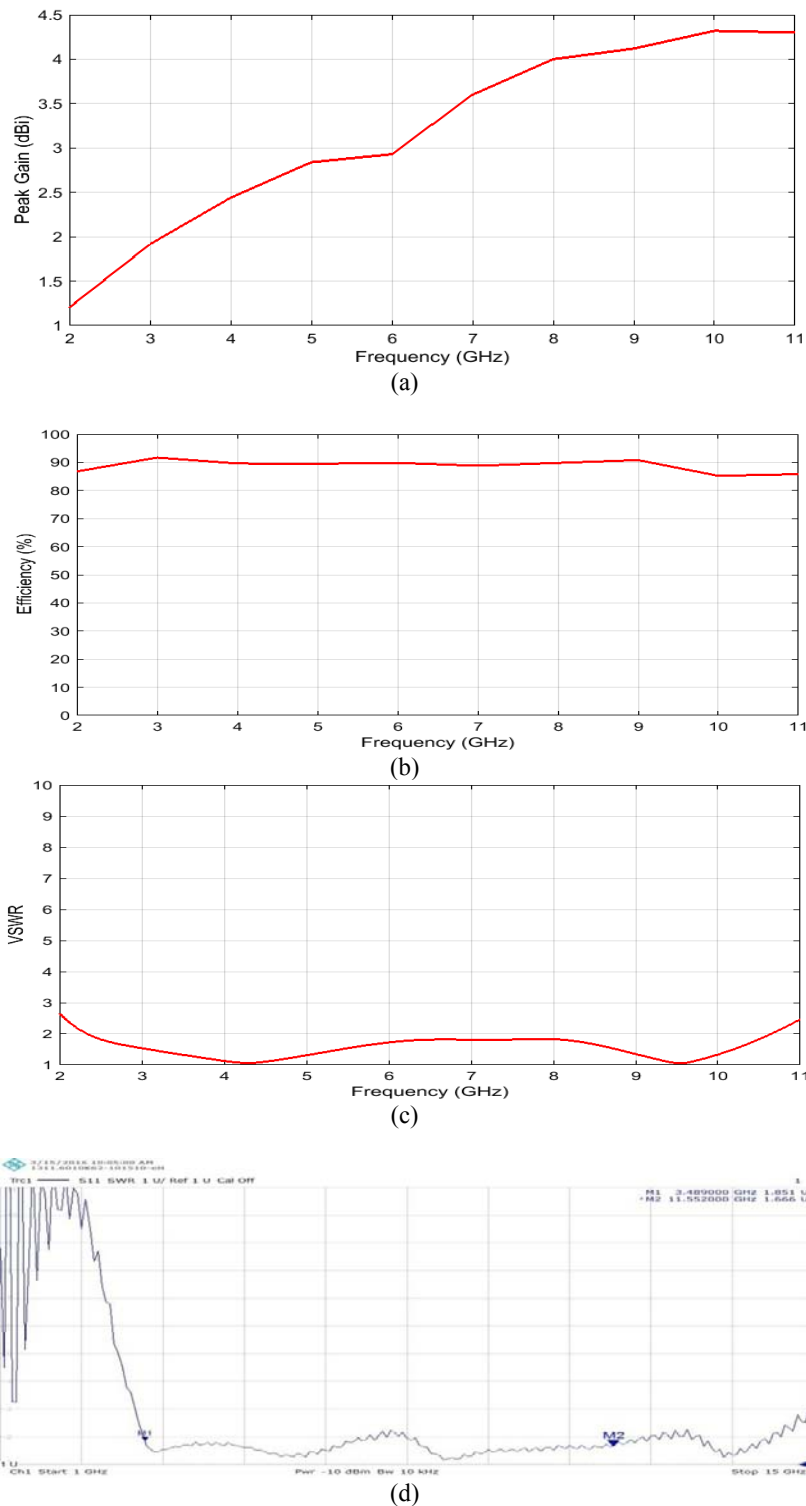


Figure-7. (a) Peak gain, (b) Efficiency of MIMO antenna, (c) VSWR (d) Measured VSWR.

4. CONCLUSIONS

A compact UWB MIMO with size of 26 x 34 mm², for portable device applications has been proposed in this work. The proposed MIMO antenna consists of two

symmetrical U-shaped slot patches as radiating elements. A long ground stub along with two rectangular slots are printed on the other side of the substrate to enhance the isolation between the antenna elements and to improve the



impedance bandwidth. Simulated and measured results indicate that the antenna can work in the entire UWB band from 2.5-10.7 GHz with mutual coupling < -20 dB. The performance characteristics of the proposed MIMO antenna gives evidence that, proposed model is a good candidate for portable UWB applications.

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