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Ultra-Wideband MIMO Antenna with Band-Notch Characteristics at WLAN Band

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ABSTRACT

In this paper, MIMO antenna exhibiting band-notch characteristics at WLAN band for Ultra-wide band applications. The proposed UWB MIMO antenna comprises of pair of identical elements fed by microstrip line feed. Three slots are etched on the ground to achieve good impedance matching properties from 3.5 to 12.6 GHz. A rectangular stub is protruded from the ground plane to enhance the isolation more than 15dB between the antenna ports. An inverted C-shaped slot is incorporated on each element to create band-notch at WLAN band from 5 to 5.6 GHz. The results show that the proposed antenna is well fit for UW applications.

Keywords: MIMO antenna, Ultra-wideband, Isolation, Band-notch, WLAN band.

1. INTRODUCTION

The present and future wireless communication systems demand for high data rate, more channel capacity, quality of service and coexistence with existed systems. Ultra-wideband technology is a promising solution because it offers higher datarates at lower emission powers, wide bandwidth, low cost and coexistence with other systems. However, UWB technology suffers from multipath fading in indoor applications. Multiple input multiple output is prominent technology to avoid multipath fading problem in UWB system. [1-3] But the MIMO systems suffer from low isolation between the antenna ports which effects the whole system performance. Several isolation enhancement methods were developed to increase the isolation. [4-8] Methods include the use of tree-like structure on the ground plane, [4] etching a T-shaped slot and a line slot on the ground, [5] protruding ground structure, [6] adopting wideband neutralization line, [7] and using a protruded ground branch structure. [8]

Since, UWB is operating from 3.1 to 10.6 GHz, there are chances to receive the frequency interference from WLAN (wireless local area network) band (5.15-5.825 GHZ). So, to mitigate the frequency interference, UWB MIMO antenna with band-notch characteristics is needed. Many techniques were proposed in the early time to reduce the interference from WLAN includes inserting λ/4 and λ/2 slot resonators on the ground plane, [9] An inverted U-slot resonator is placed on the feed line, [10] inserting open stub in the printed folded monopole, [11] microstrip lines loaded with trident-shaped strips, [12] quarter-wave stub connected to the ground. [13] In this communication, ultra-wideband MIMO antenna with band-notch feature at WLAN band is presented. The following sections discuss the antenna design, results and discussion and then conclusions.

2. Antenna Design

The proposed antenna of size 26 × 31 × 0.8 mm^3 is designed on a FR-4 dielectric substrate with ε_r of 4.3 and loss tangent of 0.0027 as shown in Figure 1. The proposed antenna elements are similar to that of the antenna presented by Mchbal A et al. [8] However, in this proposed design, an inverted C-shape slot is embedded on each antenna element to achieve band-notch characteristics at WLAN band. The optimized dimensions are given in Table 1. The antenna is simulated using Ansoft HFSS v.13. The proposed structure consists of two identical elements (which are responsible for radiation) on top of substrate. The microstrip line feeding is used to excite the antenna. Defected ground is used on the backside of the dielectric substrate. To achieve better impedance matching in turn wide bandwidth and to enhance isolation between the ports, a rectangular stub is placed between the antenna elements. The rectangular stub diverts the surface currents so that the mutual coupling gets reduced and isolations gets increased. To create band-notch properties at WLAN band, a C-shape slot is etched on each radiating element.

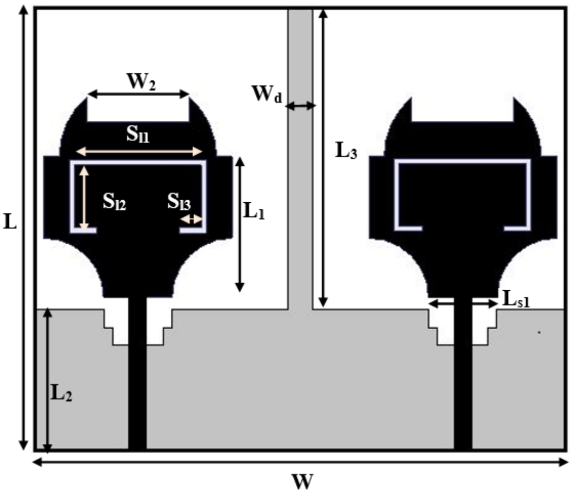


Fig. 1. Geometry of the proposed design.

Table 1. Optimized dimensions of the proposed design

L	L_1	L_2	L_f	L_{s1}	L_{s2}	W	W_1	W_2	W_d	W_f	W_{s1}
31	8.3	8	9	4	1	26	11	6	1	1	0.8
W_{s2}	S	S_1	R	R_1	T	H	S_{l1}	S_{l2}	S_{l3}	L_3	
1	0.5	1	3.5	4.6	0.035	0.8	6	4	0.3	18	

3. RESULTS AND ANALYSIS

The detailed design process of the proposed structure is given in Figure 2. Initially, the UWB MIMO antenna without decoupling structure denoted as Antenna 1 is formed by placing two antenna elements on the common ground as presented in Figure 2(a). The S11 parameter of the Antenna 1 is depicted in Figure 3. It is observed that the Antenna 1 is working from 2.5 to 10 GHz. Also, the isolation represented by (S21 parameter) between the ports is very poor as identified from the Figure 4. Antenna 2 is produced by adding a rectangular stub between the antenna elements of Antenna 1 as shown in Figure 2(b). The S11 parameter of the Antenna 2 is depicted in Figure 3. The Antenna 2 is operating from 3.5 to 12.8 GHz as seen from Figure 3. In addition, the isolation of the Antenna 2 is about 13 dB which is high when compared to Antenna 1. This enhancement of isolation is due the addition of stub between the elements. Finally, proposed band-notched antenna is formed by making inverted C-shape slots on each element of the Antenna 2.

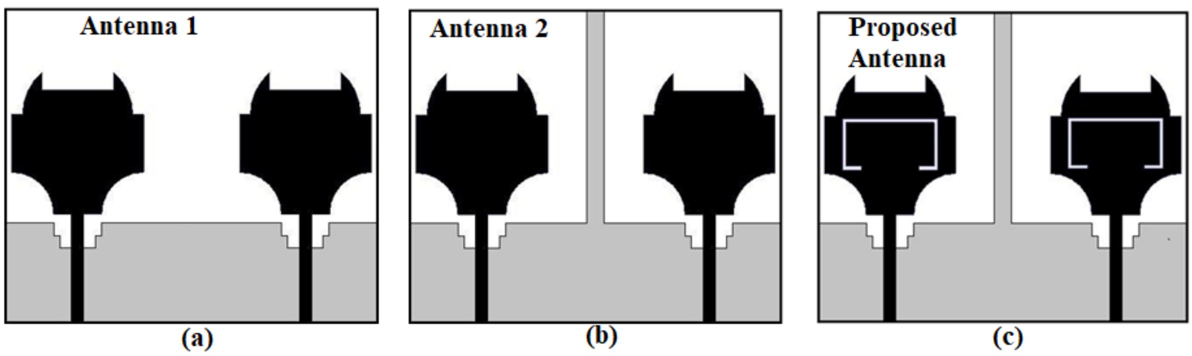


Fig. 2. Design process of the proposed antenna.

The S11 parameter of the proposed structure is presented in Figure 3. The antenna is working from 3.5 to 12.5 GHz with impedance bandwidth of 9 GHz. And the isolation of the antenna is more than 15 dB over the entire working band. In addition, a band-notch is created from 5 to 5.6 GHz to avoid the interference from WLAN systems. Figure 5 illustrates the voltage standing wave ratio (VSWR) of the three antenna configurations. The results demonstrate that the proposed antenna is well suitable for elimination of frequency interference from WLAN systems.

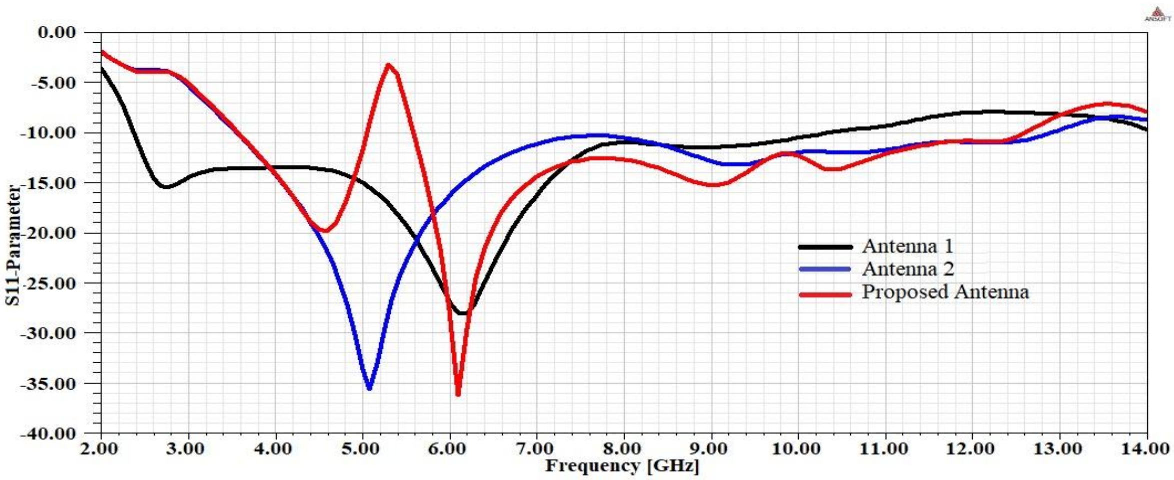


Fig. 3. The S11 parameter of three antenna configurations.

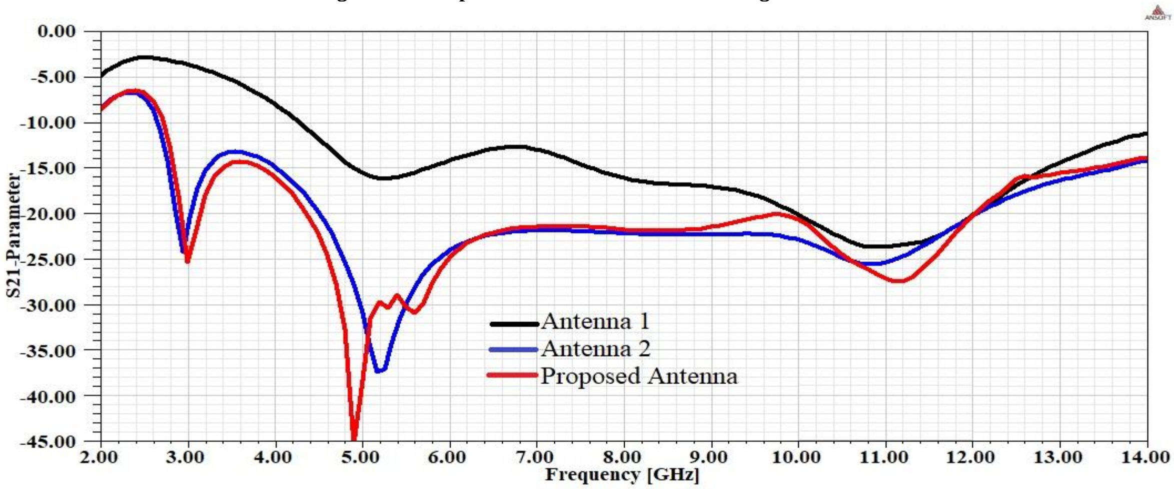


Fig. 4. The S21 parameter of three antenna configurations.

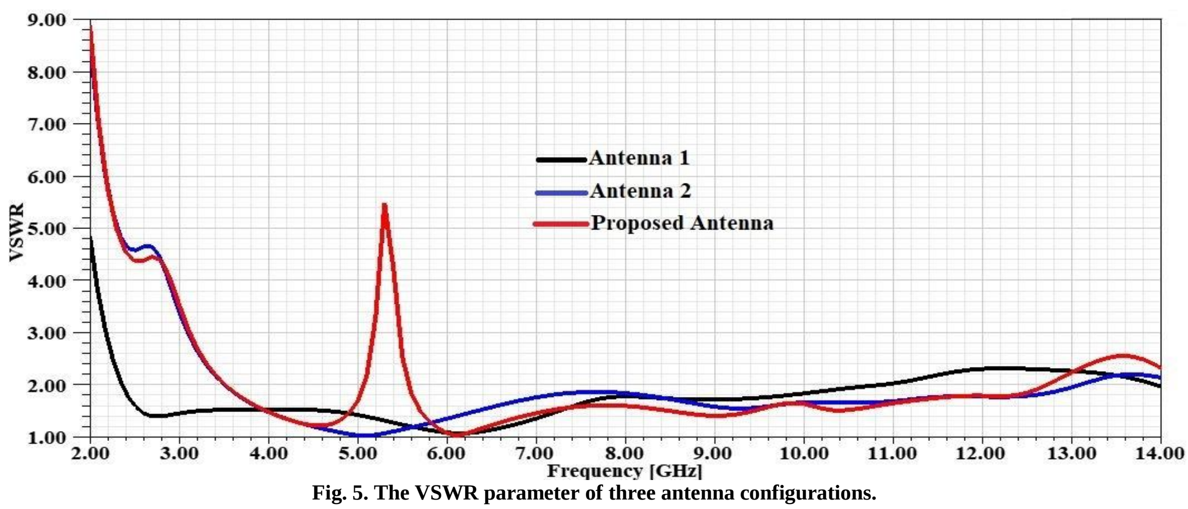
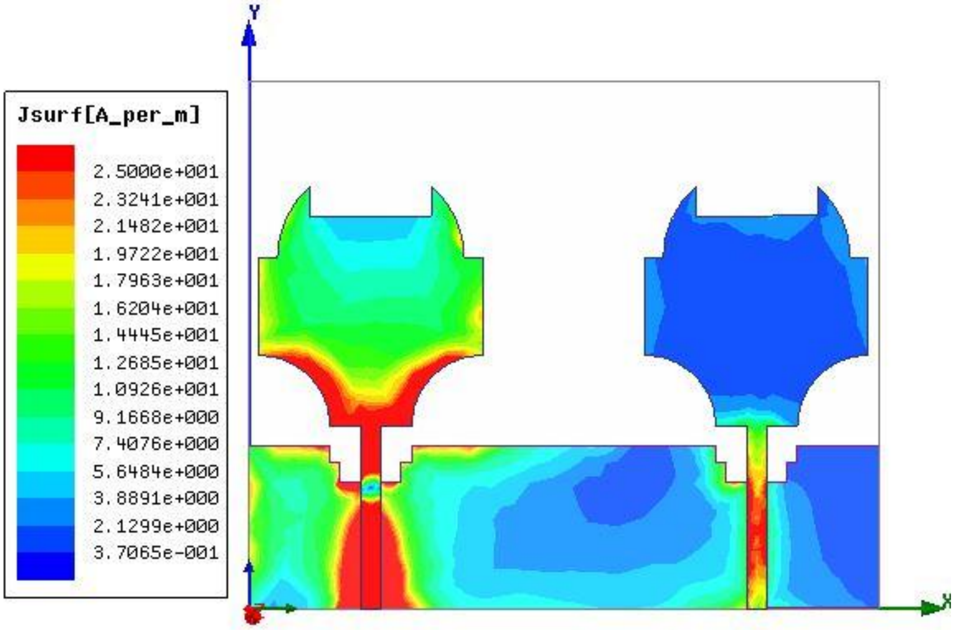
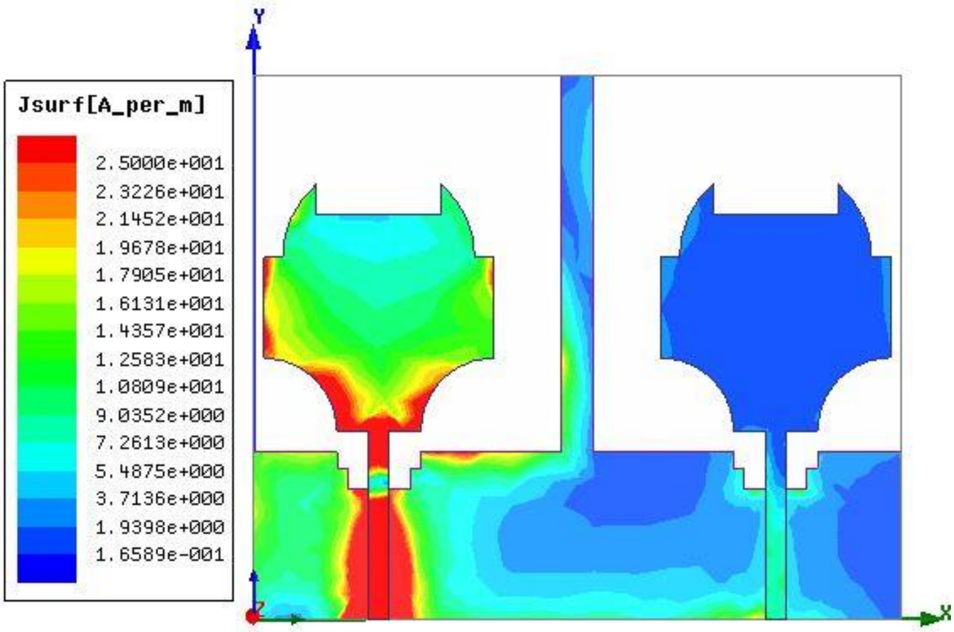


Fig. 5. The VSWR parameter of three antenna configurations.

The effect of rectangular stub extended from ground plane can be explained through surface current distribution. When port 1 is excited, the surface current distribution at 6.5 GHz of Antenna 1 and Antenna 2 are plotted in Figure 6(a) and 6(b). In the Figure 6, more radiation is indicated by red colour and less radiation is represented by blue colour. It is found from the figure that antenna with rectangular stub (Antenna 2) is blocking the radiation coming from port 1 to port 2 when compared with antenna without stub (Antenna 1). Hence, rectangular stub provides more isolation between the antenna ports such as port 1and port 2.



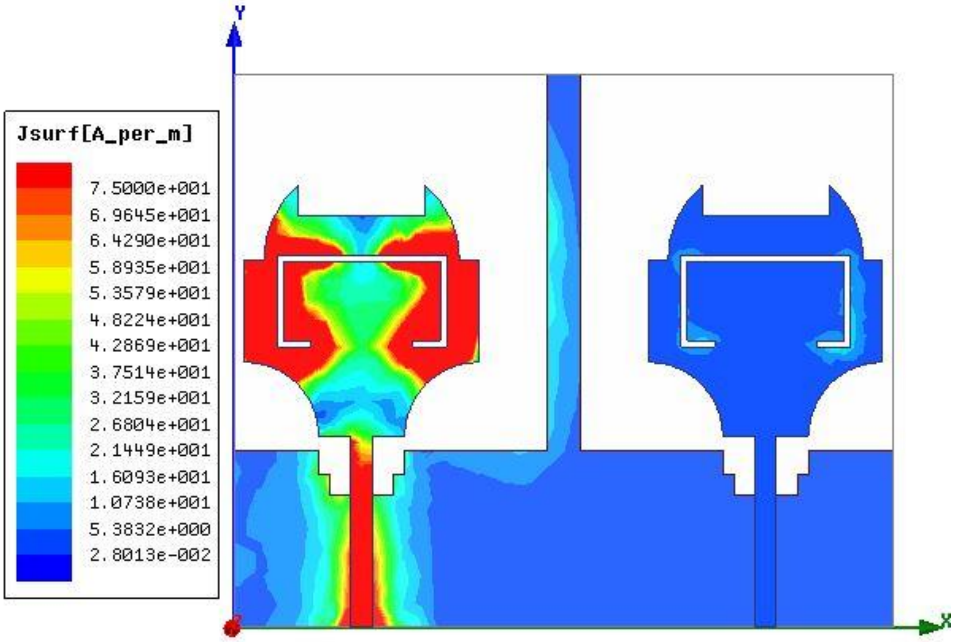
(a)



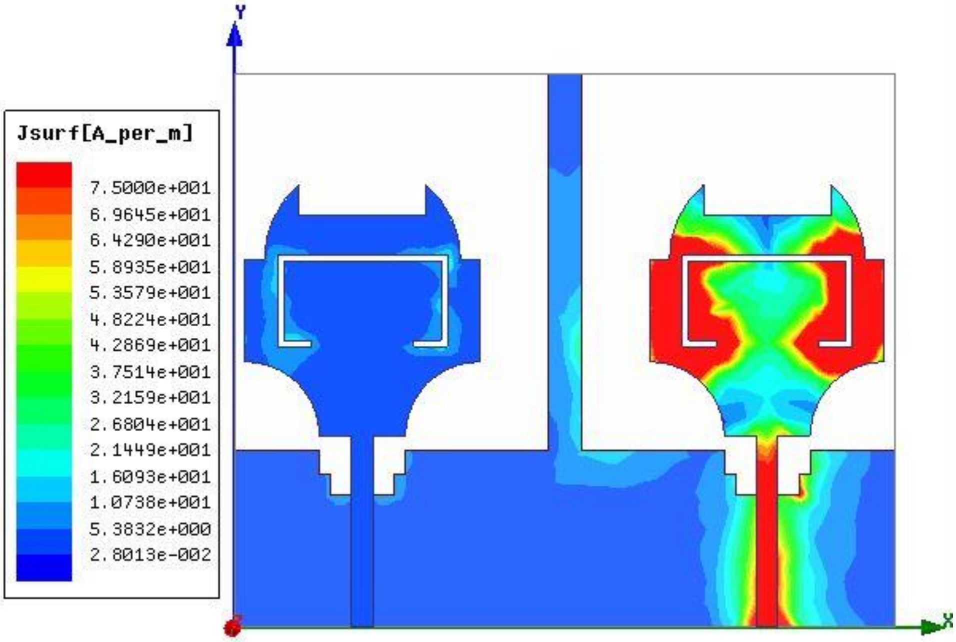
(b)

Fig. 6. The surface current distribution at 6.5 GHz when port 1 is excited: (a) Antenna 1 and (b) Antenna 2.

The inverted C-shaped slot is etched on each radiating element to suppress the frequency interference from existed WLAN system. The effect of slot on surface current distribution at 5.3 GHz when port 1 is excited and port 2 is excited is shown in Figure 7(a) and (b), respectively. It can be seen that the slot is efficiently blocking the flow of surface currents on the patch at the notch frequency 5.3 GHz.



(a)



(b)

Fig. 7. The effect of slot on surface current distribution at 5.3 GHz (a) when port 1 is excited and (b) when port 2 is excited.

The 2-D radiation patterns (E- and H-planes) of the proposed antenna at 4.6 GHz, 6.1 GHz and 9 GHz when port 1 excited and port 2 terminated with 50-ohm load and vice-versa are shown in Figure 8. It is found from the figure that the radiations patterns of the port 1 and port 2 are like mirror images manifesting that the antenna is offering good diversity performance. Also, the E-plane pattern is approximately in the form of "figure of 8 or bidirectional" and H-plane pattern is omnidirectional pattern. The results show that the proposed antenna is good choice for portable device applications.

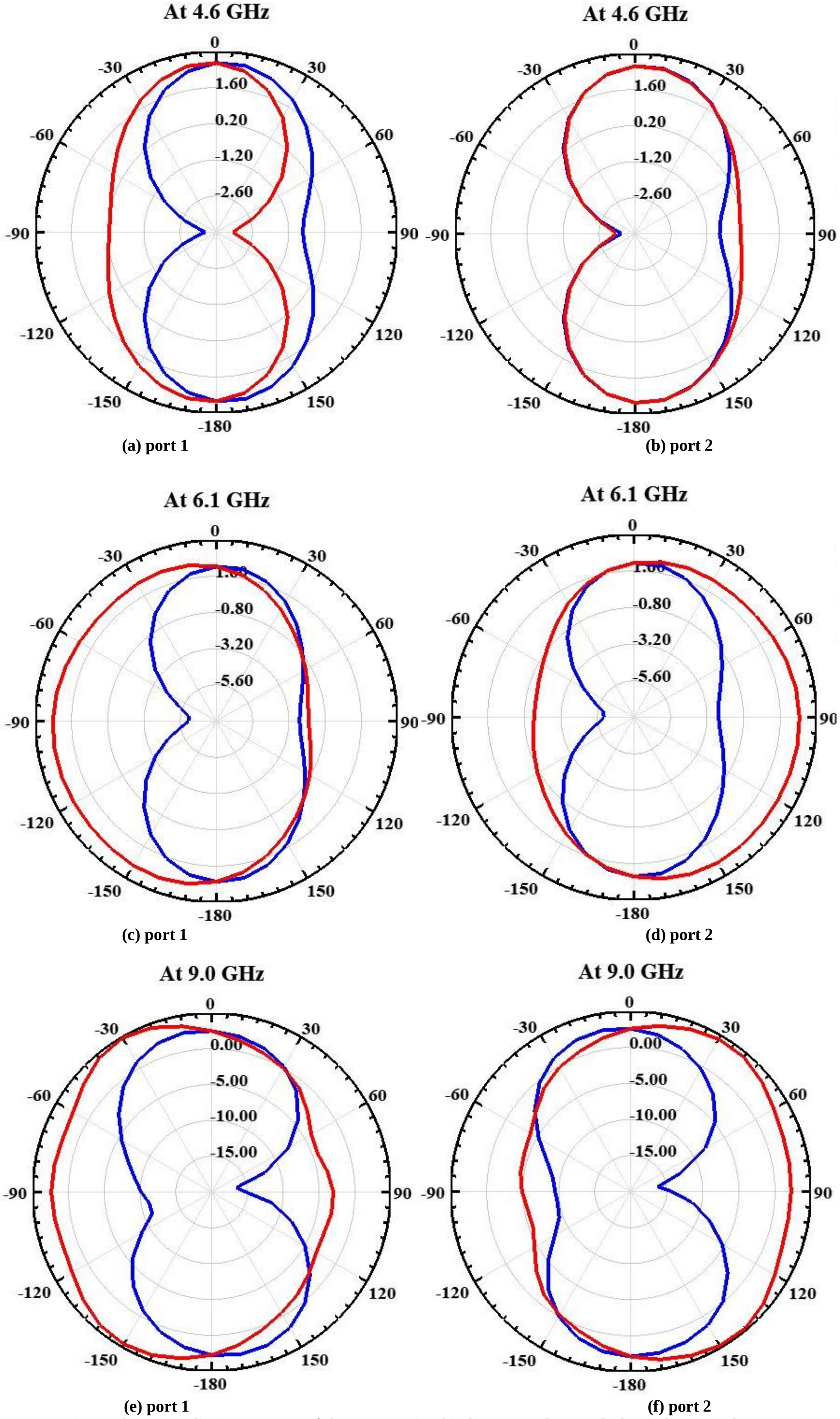


Fig. 8. The 2-D radiation patterns of the antenna (Red indicates H-plane and Blue indicate E-plane).

4. CONCLUSION

The UWB-MIMO antenna providing band-notch characteristics at WLAN band is presented in this communication. The proposed antenna contains of a couple of similar antenna elements which are excited by microstrip line feed. To achieve good impedance matching properties from 3.5 to 12.6 GHz, three slots are etched on the ground plane. And to enhance the isolation more than 15dB between the antenna ports, a rectangular stub is added to the ground. To generate band-notch at WLAN band from 5 to 5.6 GHz, an inverted C-shaped slot is placed on each element. The results confirm that the proposed UWB-MIMO antenna is good choice for portable device applications.

REFERENCES

1. Federal Communications Commission. Revision of part 15 of the commission's rules regarding ultra-wideband transmission systems. First Report and Order, FCC 02-48. 2002.
2. Kaiser T, Zheng F, Dimitrov E. An overview of ultra-wide-band systems with MIMO. Proceedings of the IEEE. 2009 Feb 27;97(2):285-312.
3. Zheng L, Tse DN. Diversity and multiplexing: A fundamental tradeoff in multiple-antenna channels. IEEE Transactions on information theory. 2003 May 7;49(5):1073-96.
4. Zhang S, Ying Z, Xiong J, He S. Ultrawideband MIMO/diversity antennas with a tree-like structure to enhance wideband isolation. IEEE Antennas and Wireless Propagation Letters. 2009 Nov 24;8:1279-82.
5. Luo CM, Hong JS, Zhong LL. Isolation enhancement of a very compact UWB-MIMO slot antenna with two defected ground structures. IEEE Antennas and Wireless Propagation Letters. 2015 Apr 15;14:1766-9.
6. Rao JC, Rao NV. CPW-fed compact ultra wideband MIMO antenna for portable devices. Indian Journal of Science and Technology. 2016 May;9(17):1-9.
7. Zhang S, Pedersen GF. Mutual coupling reduction for UWB MIMO antennas with a wideband neutralization line. IEEE antennas and wireless propagation letters. 2015 May 21;15:166-9.
8. Mchbal A, Amar Touhami N, Elftouh H, Dkiouak A. Mutual coupling reduction using a protruded ground branch structure in a compact UWB owl-shaped MIMO antenna. International Journal of Antennas and Propagation. 2018 Jan 1;2018.
9. Zheng ZA, Chu QX, Tu ZH. Compact Band-Rejected Ultrawideband Slot Antennas Inserting With λ/2 and λ/4 Resonators. IEEE Transactions on Antennas and Propagation. 2011 Feb;59(2):390-7.
10. Jetti CR, Nandanavanam VR. Compact MIMO antenna with WLAN band-notch characteristics for portable UWB systems. Progress In Electromagnetics Research. 2018;88:1-12.
11. Lee JM, Kim KB, Ryu HK, Woo JM. A compact ultrawideband MIMO antenna with WLAN band-rejected operation for mobile devices. IEEE Antennas and wireless propagation letters. 2012 Aug 21;11:990-3.
12. Jetti CR, Nandanavanam VR. Trident-shape strip loaded dual band-notched UWB MIMO antenna for portable device applications. AEU-International Journal of Electronics and Communications. 2018 Jan 1;83:11-21.
13. Khan MS, Capobianco AD, Naqvi A, Shafique MF, Ijaz B, Braaten BD. Compact planar UWB MIMO antenna with on-demand WLAN rejection. Electronics Letters. 2015 Jun 3;51(13):963-4.

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