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Design of Compact UWB MIMO Antenna with High Isolation

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Abstract: - According to the requirements of communication quality and transmission rate, a compact UWB MIMO antenna with high isolation is proposed for wireless communication system. The proposed antenna can achieve an ultra-wide band from 3.3 GHz to above 12 GHz and the isolation higher than 22.5 dB in the whole frequency range. The size of antenna element is 50 percent reduced by cutting out half of the original antenna element and the frequency band is basically unchanged. The antenna is composed of two mirror symmetrical antenna elements. An isolation strip is added between two elements to improve the isolation and a 6dB improvement of the isolation is achieved. The proposed antenna system has good radiation performance at each observation frequency points. The maximum realized gain is about 4.32dBi and the radiation efficiency is ranged from 83% to 92% at the passbands. All the results show that the proposed antenna system can be a good candidate for UWB MIMO communication applications.

Keywords: UWB; MIMO; compact; isolation; half-cut method

1 Introduction

Ultra wide band (UWB) technology has been widely concerned because of its ultra wide transmission bandwidth[1-2], high transmission rate[3-4], high security, low power consumption, low cost and many other advantages. At the same time, multiple input multiple output (MIMO)[5] technology increases the channel capacity of the communication system effectively and doubles the spectrum utilization and transmission rate of the communication system by using multiple antennas at the input and output at the same time. The combination of UWB technology and MIMO technology can make full use of their advantages and increase the transmission bandwidth and transmission rate effectively， which has broad application prospects. Therefore, it is of great significance to design an UWB MIMO antenna with high performance.

As the communication equipment becomes thinner and thinner, the space reserved for the antenna is smaller and smaller, which makes the antenna develop in the direction of miniaturization. At present, many methods have been proposed to realize antenna miniaturization, such as bending technology [6], meander technology [7], half cutting technology [8], end loading[9], loading high magnetic loss materials[10], etc. For MIMO antenna system, the integration of multiple antenna units will enhance the coupling among the units and affect the radiation performance of the antenna. Therefore, how to improve the isolation is a difficult problem in the design of MIMO antenna system. The decoupling methods of MIMO antenna system mainly include adding floor branches [11], parasitic branches[12], neutral lines [13], etching grooves [14-15], metamaterials [16], etc.

A miniaturized ultra wideband MIMO antenna with high isolation is proposed in this paper. The antenna can cover the ultra wideband band band of 3.3 ~ 12 GHz. By using the half cutting method, the size of the antenna is reduced by 50%, and the isolation branch is added between the two antenna units, so that the isolation between the antenna units is increased by 6 dB, and the isolation is higher than 22.5 db in the covered frequency band , which has a good isolation effect.

2 Materials and Methods

Figure 1 shows the structure diagram of the proposed UWB MIMO antenna. The antenna system is composed of two symmetrically placed antenna units with the same structure. The antenna is

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printed on FR4 dielectric board with relative dielectric constant of 4.4 and thickness of 1.6 mm. The front of the antenna unit is composed of a semicircular radiation patch fed by a 50 Ω feeder, and the back is a slotted grounding plate. In order to reduce the coupling between the two antenna units, a rectangular isolation branch is placed between the antenna units. The specific structural dimensions of the antenna are given in Table 1.

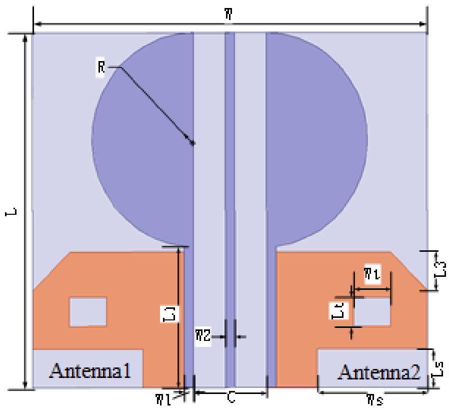
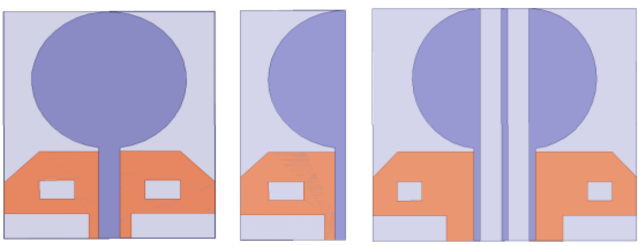


Fig. 1 Schematic configuration of the proposed compact UWB MIMO antenna

Table 1 Design parameters of the proposed UWB antenna

parameter	dimension/(mm)	parameter	dimension/(mm)
W	43	*L*3	4
L	36.5	*Lt*	3
R	11	*Wt*	4
*W*1	2	*Ls*	4
*L*1	14.5	*Ws*	12
*W*2	1	*C*	4

In order to further illustrate the design process of the antenna, Figure 2 shows the structural evolution diagram of the designed antenna. Antenna (a) is a symmetrical antenna structure, which can be miniaturized by half cutting method. A half cut antenna is constructed based on the half cut method as shown in antenna (b). The size of the antenna is greatly reduced. However, the asymmetry of the half cut antenna leads to the asymmetry of the radiation mode, which reduces the efficiency and gain of the antenna. In order to overcome these shortcomings, the left and right antenna units are symmetrically placed on both sides of the dielectric substrate to form 2×2 MIMO system, and in order to reduce the coupling between antenna units, an isolation branch is added between antenna units as shown in antenna (c). Figure 3 shows the return loss diagrams of the three antennas respectively. It can be seen that the frequency band covered by the half cut antenna is basically the same as the original antenna.



(a) (b) (c)

Fig. 2 The evolution of antenna structure

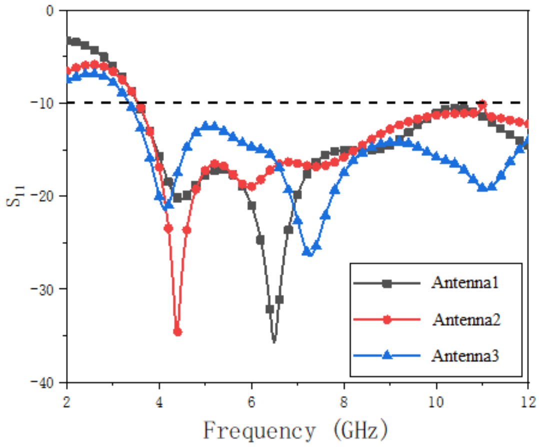


Fig. 3 The return loss of three antennas

3 Results and Discussion

Figure 4 shows the S parameters of the proposed UWB MIMO antenna. It can be seen from the figure that the antenna covers the UWB frequency band from 3.3 to 12 GHz, and the coupling between antenna units is less than - 22.5 db within the frequency band covered.

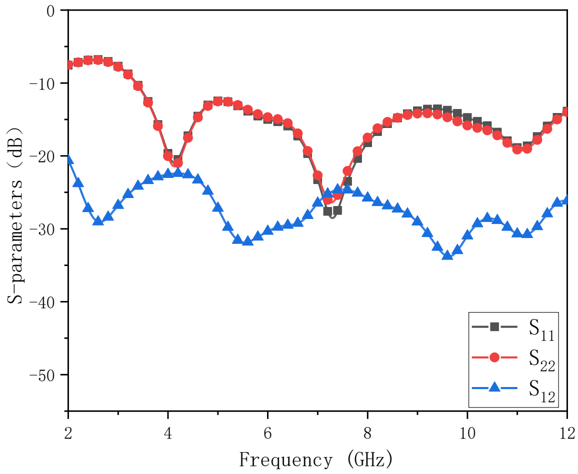


Fig. 4 S-parameters of the proposed compact UWB MIMO antenna with high isolation

In order to verify the decoupling effect of isolated branches, Figure 5 shows the S-parameters simulation results of UWB MIMO antennas with and without isolated branches respectively. It can be seen from the figure that after adding decoupling branches, S11 and S22 of the two antenna units basically have no change, the isolation between antenna units has been significantly improved, and S21 has been reduced by 6dB mainly in the whole frequency band.

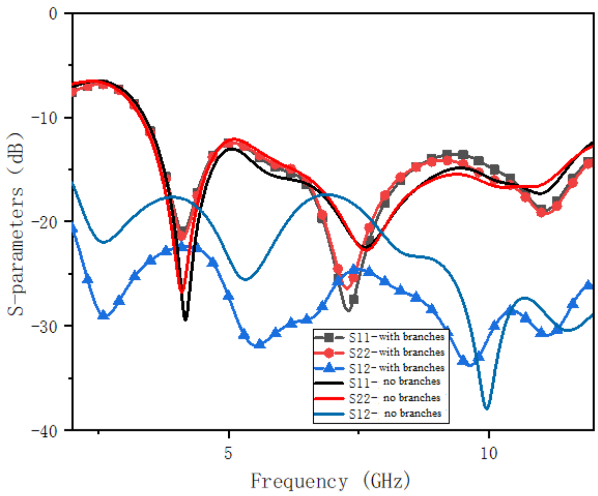


Fig. 5 Simulated S-parameters of UWB MIMO antenna with isolation strip and without isolation strip

Figure 6 shows the comparison of current distribution of UWB MIMO antenna with and without isolated branches. It can be seen from figure (a) that there is obvious coupling current on the right antenna unit when no isolation branch is added. After adding the isolation branch, as shown in figure (b), the coupling current disappears basically. Therefore, it can be concluded that the isolation effect of the isolation branch is good.

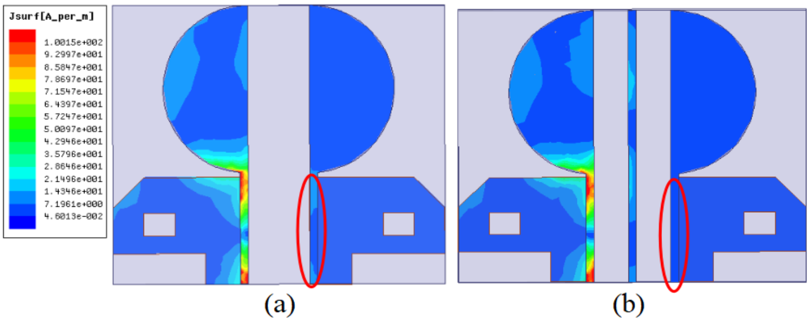


Fig. 6 Simulated current distribution of UWB MIMO antenna (a) without isolation strip (b) with isolation strip

Figure 7 shows the radiation patterns of antenna 1 and antenna 2 at different frequency points. It can be seen from the figure that the radiation modes of the two antenna units have complementary and symmetrical characteristics at the same frequency point, which is conducive to combating multi-path fading. At the same time, this structure also offsets the asymmetry of radiation mode caused by the asymmetry of the half cut antenna and makes up for the lack of antenna efficiency and gain. It can be concluded that the radiation effect of the two antenna elements is good at each frequency point. Figure 8 shows the gain and radiation efficiency of the whole antenna. It can be seen from the figure that the radiation efficiency of the antenna in the whole frequency band is between 83% ~ 92% and the maximum gain is 4.35 DBI.

Finally, the designed antenna is processed into a physical product, so the S-parameters of the antenna measured and simulated can be compared with each other, as shown in Figure 8. It can be seen from Figure 9 the measured results are consistent with the simulated ones mainly, and the little error between them are caused mainly by the error of the antenna in the processing process, the influence of SMA welding and the influence of test environment.

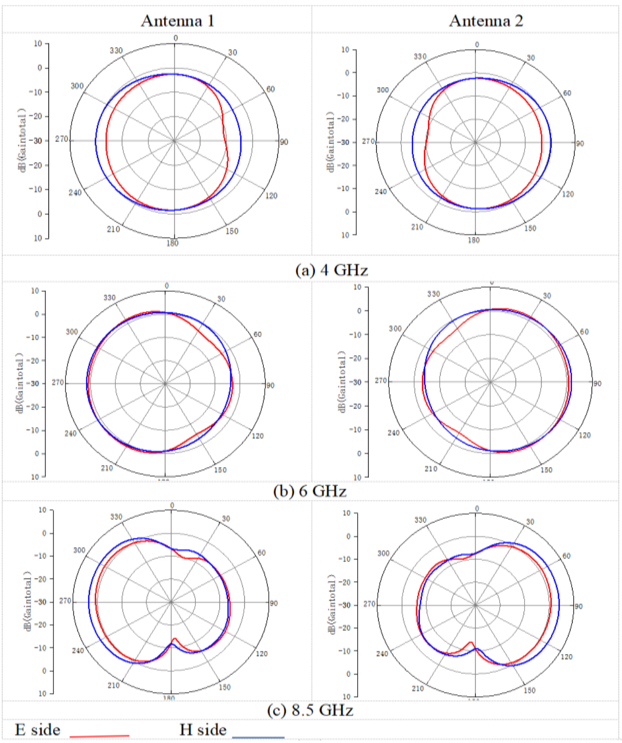


Fig. 7 Radiation patterns for Ant1 and Ant 2 at different frequencies

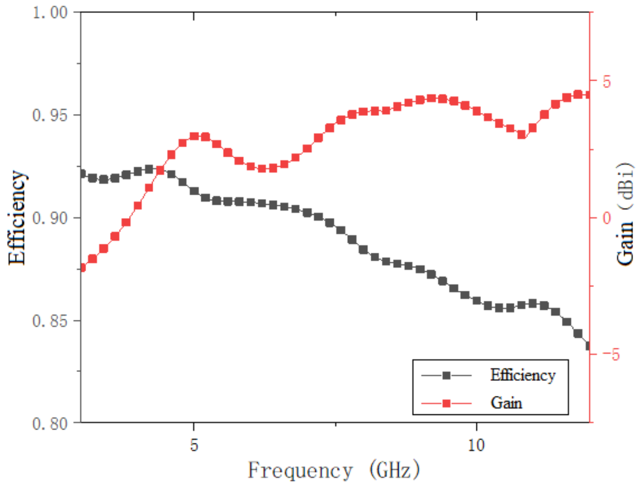


Fig. 8 Antenna gain and radiation efficiency of the proposed UWB MIMO antenna

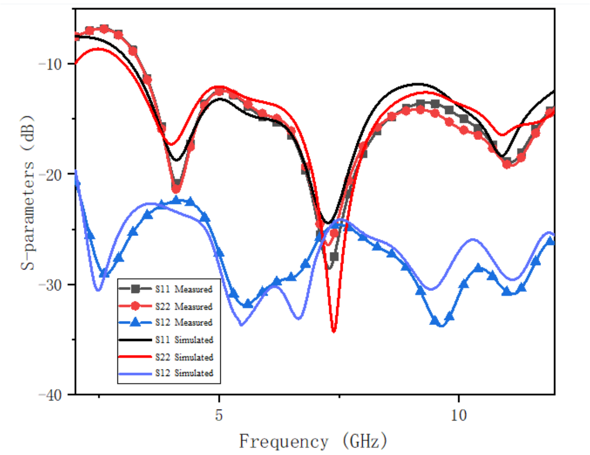


Fig. 9 Measured and simulated S-parameters of the proposed UWB MIMO antenna

4 Conclusion

A compact UWB MIMO antenna with high isolation is proposed in this paper. The antenna is miniaturized by half cutting method and high isolation is achieved by adding isolation branches. The proposed antenna can cover the UWB band of 3.3~12 GHz, and the isolation is higher than 22.5 db. By cutting half of the original symmetrical antenna, the size of the antenna unit is reduced by 50%, at the same time the half cut antenna can still cover the frequency band of the original antenna, but the asymmetry of the antenna after half cutting leads to the asymmetry of the radiation mode which reduces the efficiency and gain of the antenna.Therefore a 2×2 MIMO antenna system is constructed in order to overcome this shortcoming. By placing an isolation branch between the two antenna units, the isolation is effectively improved. The results show that the compact UWB MIMO antenna has excellent performance and can meet the requirements of wireless communication system.

Compliance with Ethical Standards

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, author-ship, and/or publication of this article.

Data Sharing Agreement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Research involving Human Participants and/or Animals

Not applicable.

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