A Compact Dual-Element MIMO Antenna with High Isolation for Wideband Applications

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1 Introduction

In the contemporary wireless communications system, there is a need for high channel bandwidth, fast data connections, smart multimedia and improved spectrum performance. These basic needs could well be provided by MIMO antenna systems. In MIMO antenna system, the transmitter and the receiver are equipped with multiple antennas provided there is minimum coupling to achieve among the ports of antenna elements. However, it is a great challenge among the researchers to achieve very low coupling among the ports of antenna elements. Therefore, maintaining low coupling is one of the major parameters in MIMO system [1].

Nowadays, there are many techniques available to mitigate mutual coupling between antenna elements, such as etching slot on the ground structure [2], using metal strip reflector [3], adopting orthogonal mode [4], adding self-curing decoupling with capacitive loads [5] and inserting parasitic stubs between antenna elements [6]. Moreover, isolation can also be increased by incorporating defected ground plane [7], electromagnetic band gap structure [8] and maintaining suitable gaps between the antenna elements.

In this paper, a wideband MIMO antenna consisting of two antenna elements has been proposed and analyzed. The antenna occupies a compact size of 28×32 mm^2 and offers broad frequency bandwidth ranging from 3.15 GHz to 8.5 GHz with good isolation.

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2 Antenna Design

Figure 1 illustrates the configuration of MIMO antenna structure. The MIMO antenna has got FR4 as substrate whose dielectric constraint is $\varepsilon_r = 4.4$. It occupies a compact size of 28×32 mm^2 whose thickness is 1.6 mm. The proposed MIMO antenna contains two similar antenna elements separated by an I-shaped ground stub with partial ground plan. The numerical analysis of the antenna structure was performed by using Ansys electromagnetic simulation software HFSS. The final optimized numerical constraints for the proposed MIMO antenna are recorded as follows (in millimeters): $W = 32$ mm, $L = 28$ mm, $L_g = 10.5$ mm, $w_p = 3$ mm, $w_1 = 14$ mm, $w_2 = 2$ mm, $w_3 = 5$ mm, $w_4 = 1$ mm, $w_5 = 2$ mm, $w_6 = 6.5$ mm, $l_1 = 5$ mm and $l_2 = 14.75$ mm.

To study the effect of I-shaped ground stub on isolation, the current distributions are analyzed at 3.45 GHz by exciting only port 1 as depicted in Fig. 2. Figure 2a demonstrates that a strong surface current is transmitted from port 1 to port 2, due to which there is very low isolation in this case. Further, Fig. 2b shows the surface current coupling from port 1 to port 2 is found to be reduced when the I-shaped ground stub is introduced. The consequence is that high isolation has been provided between the antenna elements. The corresponding S parameters are also studied as shown in Fig. 3 in which the impedance bandwidth is found to be improved as well as the isolation (S_{21}) is enhanced by employing the I-shaped stub.

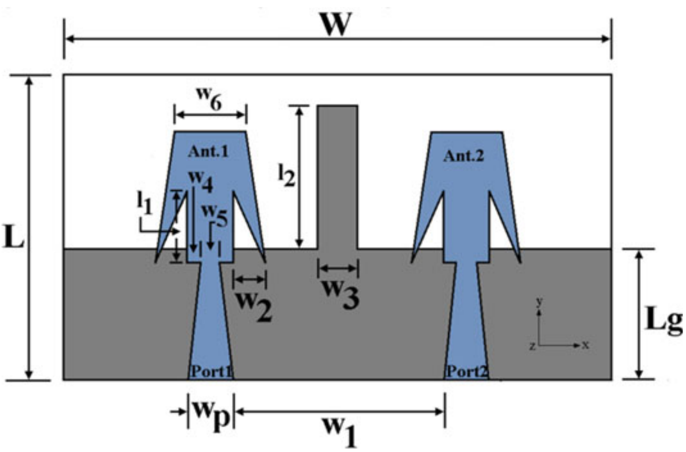

Fig. 1 Geometry of the proposed wideband MIMO antenna

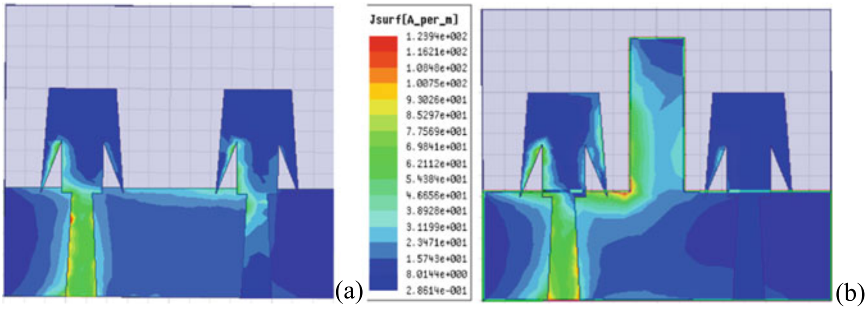

Fig. 2 Current distributions for antennas at 3.45 GHz **a** without I-shaped stub and **b** with I-shaped stub

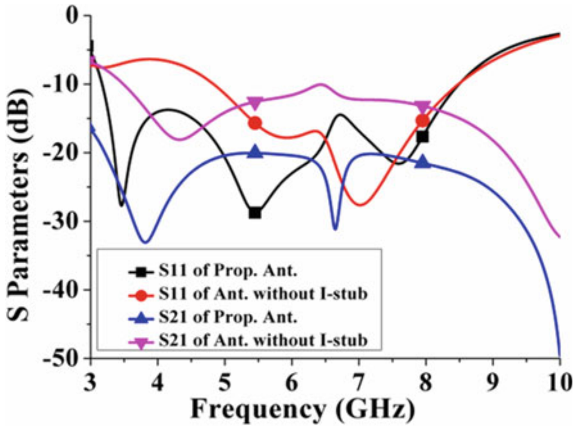

Fig. 3 S parameters of the proposed antenna with and without I-shaped ground stub

3 Results and Discussion

3.1 S Parameters

Figure 4 describes the simulated S parameters of the proposed MIMO antenna. It is seen that the MIMO antenna offers an operation bandwidth from 3.15 to 8.5 GHz for S_{11}<-10 dB. A high isolation, which is more than 20 dB over the entire frequency spectrum, is achieved.

3.2 Diversity Performance

The simulated ECC and DG curves are shown Fig. 5a, b, respectively.

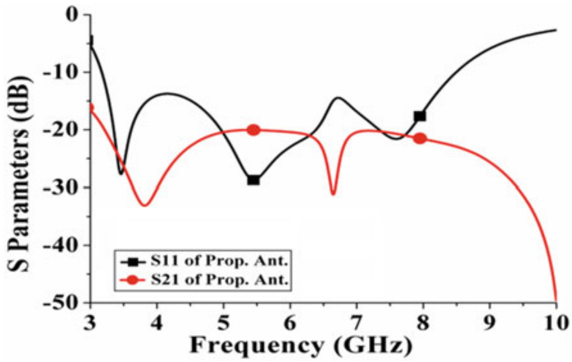

Fig. 4 S parameters of the proposed antenna

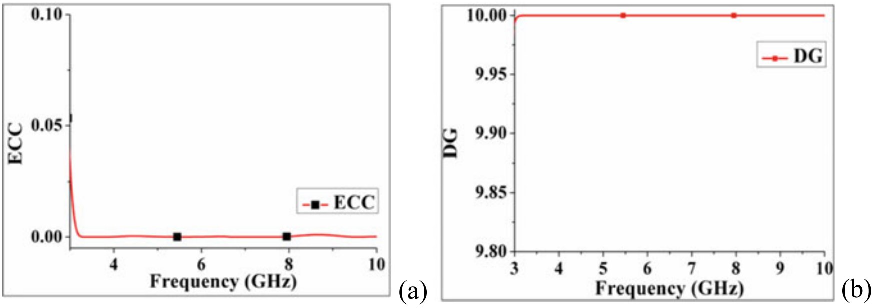

Fig. 5 Simulated **a** envelop correlation coefficient, **b** diversity gain of the proposed antenna

The figures also show that the simulated ECC value is found to be below 0.02 which is less than the maximum acceptable ECC value of less than or equal to 0.5. Moreover, diversity gain is found to be greater than 9.95 dBi throughout the entire frequency spectrum which ranges from 3.15 to 8.5 GHz.

3.3 Radiation Characteristics

The simulated radiation patterns of the proposed MIMO antenna are analyzed by exciting only port 1. Figure 6a, b depict the radiation patterns under *xoz*- and *yoz*-planes at 3.45 GHz and 5.45 GHz, respectively. The far field radiation pattern shows that field distribution is omnidirectional at 3.45 GHz and 5.45 GHz, respectively.

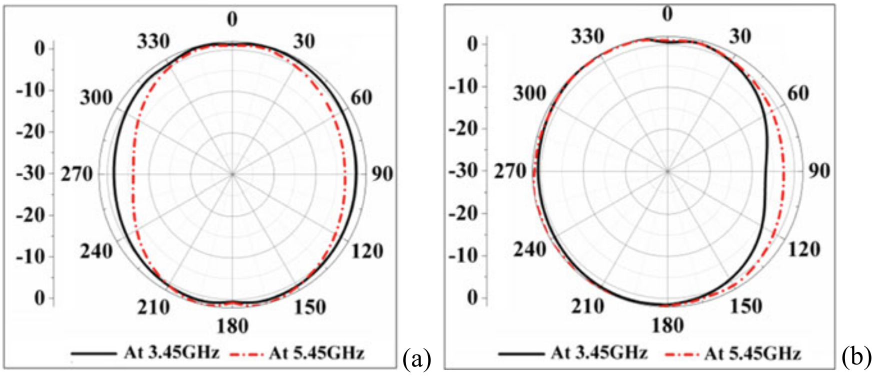

Fig. 6 Simulated radiation patterns of the MIMO antenna on **a** XOZ- and **b** YOZ-planes

4 Conclusion

The proposed work presents a compact MIMO antenna having a size of 0.32 $\lambda_0 \times$ 0.36 λ_0 for application in wideband spectrum. The operation frequency band of the antenna ranges from 3.15 to 8.5 GHz. The isolation is less than −20 dB throughout the operating band which confirms very good isolation in the MIMO system. The ECC value is found to be less than 0.02 and diversity gain is greater than 9.95 dBi throughout the band.

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