Three Port MIMO Antenna for 4G Application

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ABSTRACT

A design for a novel compact microstrip planar MIMO antenna system suitable for 4G application is presented. A decoupling network was introduced to improve the MIMO antenna ports isolation. The MIMO antenna resonates at 5.1 GHz, 5.29 GHz, 6 GHz, 6.1 GHz, 11.4 GHz and 11.92 GHz for VSWR ≤ 2 and good port isolation. The MIMO antenna system can be configured to be a two-port of three-port system. A prototype of the MIMO antenna system was fabricated and measured.

Keywords : SISO, MIMO, 4G, LTE

1 INTRODUCTION

Modern day communication systems present a challenge for communication engineers. Fourth generation (4G) technology, such as World Wide Interoperability for Microwave Access (WiMax) and Long Term Evolution (LTE), provide higher data rates in mobile services. 4G technology relies greatly on Multiple-Input-Multiple-Output (MIMO) systems, rather than classical Single-Input-Single-Output (SISO) systems. MIMO systems employ multiple antennas at both the transmitter and receiver. Higher data rates can be achived by employing MIMO systems [1].

The basic principle beyond MIMO antenna design is to reduce the correlation between the received signals among the antenna ports and maximize channel capacity. This can be achieved by employing diversity techniques [2] or use of decoupling networks. Other decoupling techniques are presented in [3], [4], [5]. The parameter that defines the correlation between signals is the mutual coupling. The mutual coupling mainly depends on the distance between the elements of the MIMO system. Increasing this distance can reduce the mutual coupling between the elements. However, this distance is limited due to the small area in which the antennas are placed, for example in a mobile handset.

In this paper, we present a design for a novel compact microstrip planar MIMO antenna system. A decoupling network is introduced to improve the antenna ports isolation. Details of the antenna design are presented in section 2. Simulated and measured results are discussed in section 3.

2 ANTENNA DESIGN

2.1 Single Port Configuration

The designed antenna in [6], achieves unltra wideband (UWB) from 17-30 GHz, having the feed position placed at the center of the arc. The implementation of partial ground and allocating slots on the patch, allows us to generate different frequency bands as shown in [6]. This can also be solved by changing the feed position along the arc. In our proposed structure, shown in Fig. 1, by changing the feed position along the arc and allocating VIA's on the patch edge, the same frequency bands as in [6] can be generated. The antenna has a circumference of 52 mm. The overall area of the substrate simulating the ground plane for the antenna is 35 x 32 mm². Substrate material FR-4 with ε_r = 4.65 and h= 1.6 mm was used. The structure consists of a rectangular patch sitting on a circular sector.

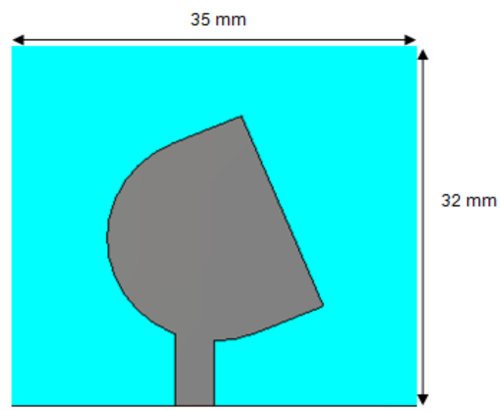

Fig. 1. Geometry of single port antenna.

2.2 MIMO Antenna Configuration

Fig.2 below shows the configuration of a three port MIMO antenna. To improve the ports isolation, a decoupling network was designed by using the same substrate material as shown in Fig. 3. The decoupling network consists of two elements having similar dimensions. The dimensions of the network can be optimized to achieve the desired pass band frequency. The separation between the elements can be changed to improve the MIMO antenna ports isolation.

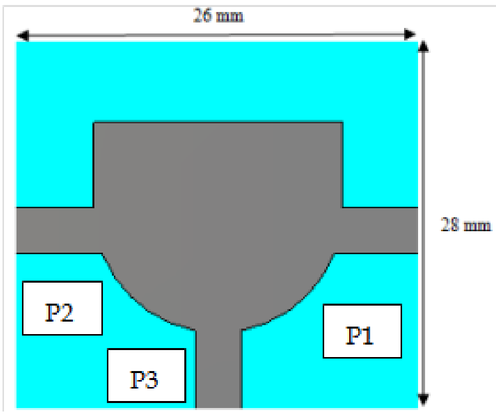

Fig. 2. Three port antenna configuration.

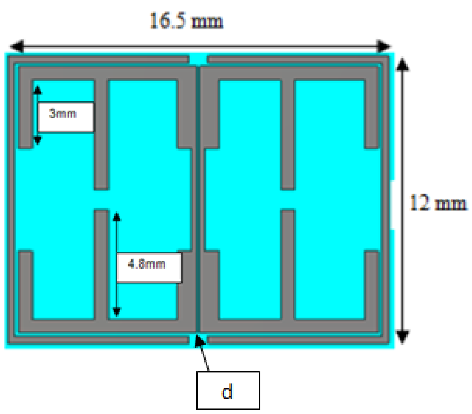

Fig. 3. Decoupling network.

2.3 MIMO Antenna Employing Decoupling Network

Fig. 4 shows the configuration of the MIMO antenna system employing the Decoupling network. The networks are placed at the feed lines of the antenna. The overall dimension of the MIMO system is 68 x 50 mm².

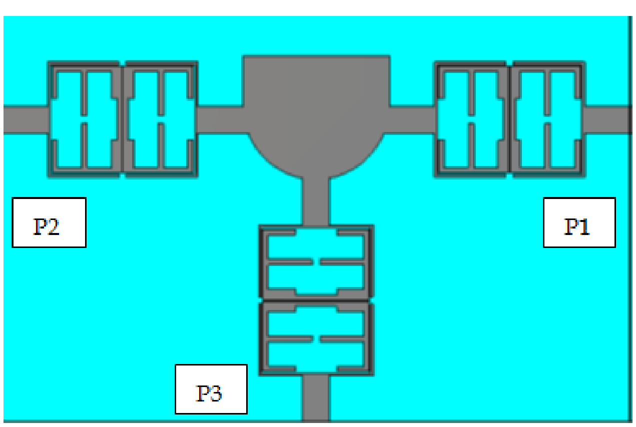

Fig. 4. MIMO antenna with decoupling network.

3 Simulated and Measured Results

The Simulated S-parameter for the single port antenna is shown in Fig. 5. The antenna achieves dual modes at 5.15 GHz, and 8.14 GHz.

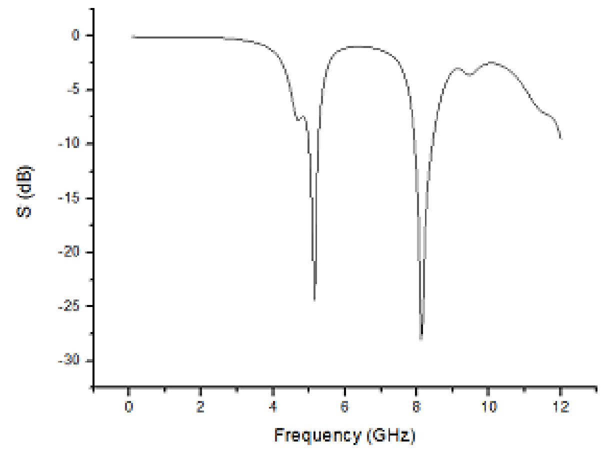

Fig. 5. Simulated S-parameter for single port antenna.

Fig. 6 shows the simulated S-patameter for the MIMO antenna system without the decoupling network. The antenna resonates at 4.92 GHz, 8.85 GHz, and 10 GHz. We can see from the graph that port one and port two (P1 & P2) match each other (S11 & S22). This is due to the symmetry of their positions along the patch sides. The ports exhibit good insertion loss, below -20 dB, at 4.92 GHz and 8.85 GHz, but are highly coupled at 10 GHz. Port one and port two can be configured so they both transmit with port three receiveing or viseversal.

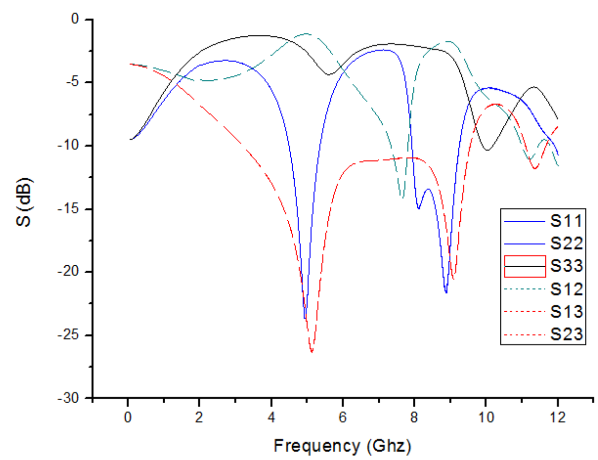

Fig. 6. Simulated S-parameter for MIMO antenna without decoupling Network.

The simulated S-parameter for the decoupling network is shown in Fig. 7. The MIMO antenna system employing the decoupling network was fabricated using thin film and photolithographic technique and measured by using vector network analyzer. A photograph of the fabricated MIMO antenna system is shown in Fig. 8. Fig. 9 shows the simulation results for

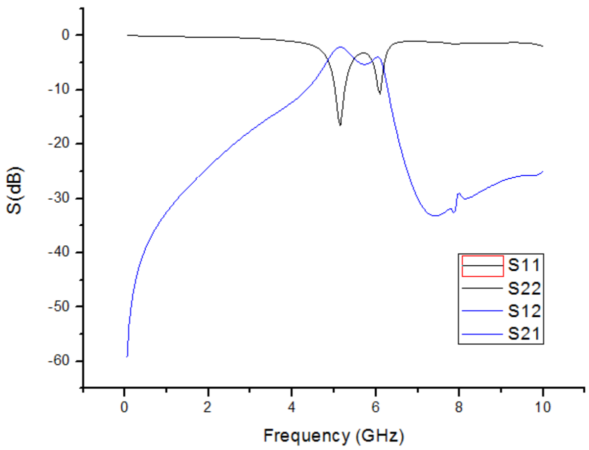

Fig. 7. Simulated S-parameter for the decoupling network.

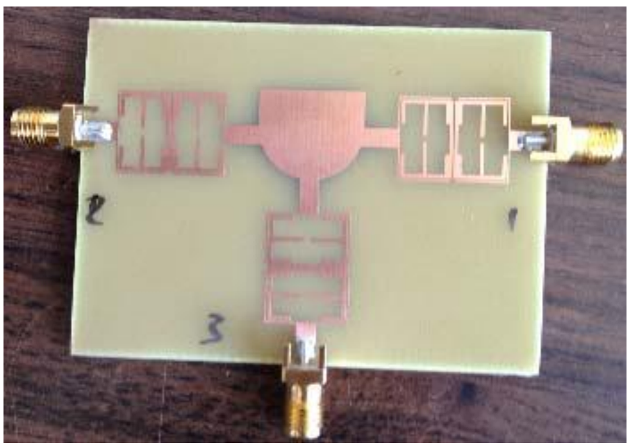

Fig. 8. Fabricated MIMO antenna.

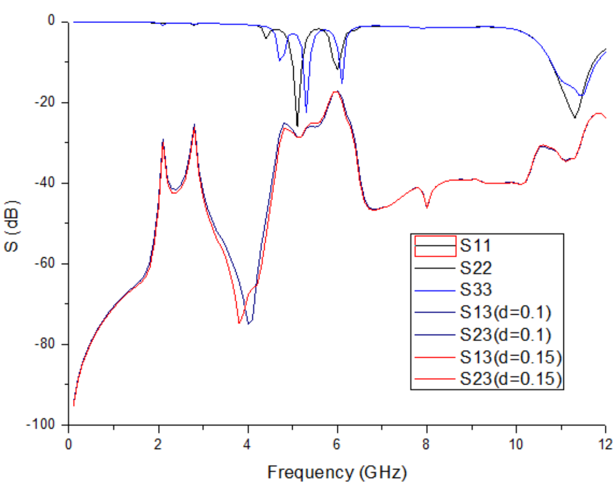

Fig. 9. Simulated S-parameters for the MIMO antenna with decoupling network.

the MIMO antenna employing the decoupling network for different element separation *d*.

The measured return loss (S11 and S33) and insertion loss (S13) for the MIMO antenna system employing the decoupling network is shown in Fig. 10. The MIMO antenna exhibits good

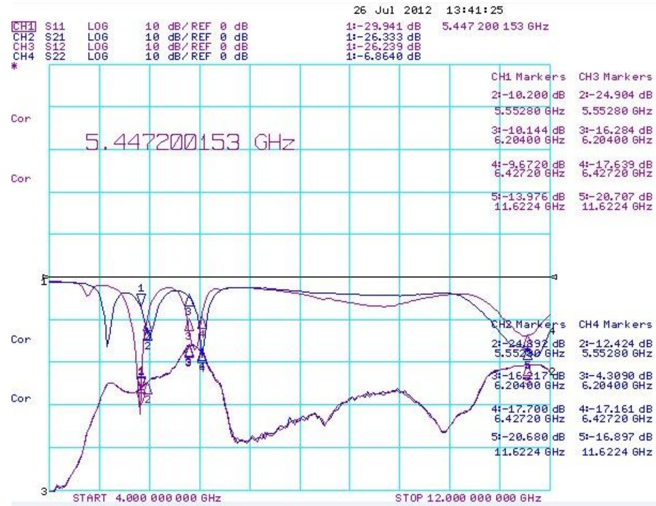

Fig. 10. Measured S-parameters for MIMO antenna employing the decoupling network.

port isolation.

4 Conclusion

In this paper, a design for a novel compact single element planar MIMO antenna system suitable for 4G application is presented. The antenna covers a range of frequencies from 4-12 GHz. The presented MIMO antenna consists of three ports wuth a new decoupling network to improve the MIMO antenna ports isolation. The MIMO antenna system was fabricated on FR-4 substrate with an overall area 68 x 50 mm². Simulated and measured resuts for the S-parameters were presented. Good agreement was found between the simulated and measured results.

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