

Research Article

Multiband Planar Monopole Antenna for LTE MIMO Systems

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A novel multiband-printed planar monopole antenna for LTE multi-input and multi-output (MIMO) application is proposed. A meandering microstrip line-loaded monopole antenna with multiband characteristic is presented. The proposed antenna provides five frequency bands for LTE application, covering 0.7, 1.7, 2.1, 2.3, and 2.5 GHz. In order to provide low mutual coupling and envelope correlation, two of the antennas are combined with orthogonal polarizations. The mutual coupling of the antenna is lower than -13 dB across the operation bands. Both the simulated and measured results are shown to illustrate the performances of the proposed antenna.

1. Introduction

Nowadays, there are more and more interests in research on multi-input and multi-output (MIMO) systems in the wireless communication. Since it has the ability to increase the capacity of channel using the spatial properties of multipath, it is necessary to have a number of uncorrelated antennas at each end of the communication link. So it seems to be very essential to design adequate antenna due to use in MIMO systems. As revealed in many literatures [1–4], both of non-printed MIMO antennas such as planar-inverted F antennas (PIFAs) and printed MIMO antennas are proposed. However, among the antennas which are used for MIMO application, printed antennas are more appropriate due to their low cost, easy fabrication, and their capability of easily being integrated to small terminal devices. Rapid developments in the wireless communication require novel antenna designs which can be used for multifunctional systems, which means that the antenna should have more than one frequency band. A tri-band E-shaped printed monopole antenna loaded with two U-shaped resonance paths suitable for MIMO systems for WLAN application, covering 2.4, 5.4, and 5.8 GHz, is reported in [5].

In this paper a novel multiband-printed planar monopole antenna for LTE MIMO application is presented. It can provide five frequency bands for LTE applications, covering

746–787 MHz, 1710–1755 MHz, 2110–2155 MHz, 2305–2400 MHz, and 2500–2690 MHz. This multiband characteristic is obtained by loading a meandering line to an ultra-wideband planar monopole antenna. Two elements of such antennas are used for MIMO applications. The proposed structure obtains low mutual coupling and envelope correlation due to the orthogonal polarization.

2. Antenna Structure and Mechanism

As we know, printed planar monopole antennas have been widely used in wireless communication devices. They are very popular for volume-limited and wideband applications. The structure of the proposed multiband MIMO antenna is shown in Figure 1. This antenna is printed on an FR-4 substrate with relative permittivity 4.4 and thickness of 1.6 mm. The two identical antenna elements have the same structure and dimensions. The antenna has two layers, the top layer and the bottom layer. On the bottom layer there are the grounds with length L_g and width W_g . On the top layer is the microstrip line-loaded monopole. The antenna is fed by a microstrip line with width 3 mm to match 50Ω . The monopole is rectangular with width W_2 and length L_1 and L_2 . The loaded microstrip line has width W_{strip} and length of one path L_{strip} . The two antenna elements are spaced

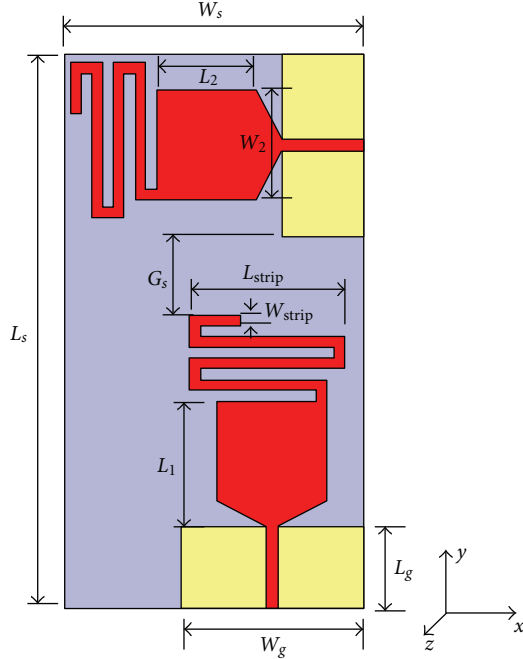


FIGURE 1: The geometry of the proposed antenna.

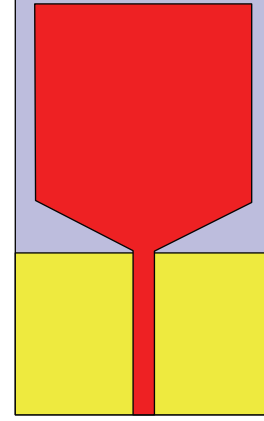
TABLE 1: Antenna dimensions.

Dimension	L_s	W_s	L_g	W_g	L_1
Size (mm)	153	83	22.7	50	34.8
Dimension	L_2	W_2	L_{strip}	W_{strip}	G_s
Size (mm)	27.7	50	40	3	20

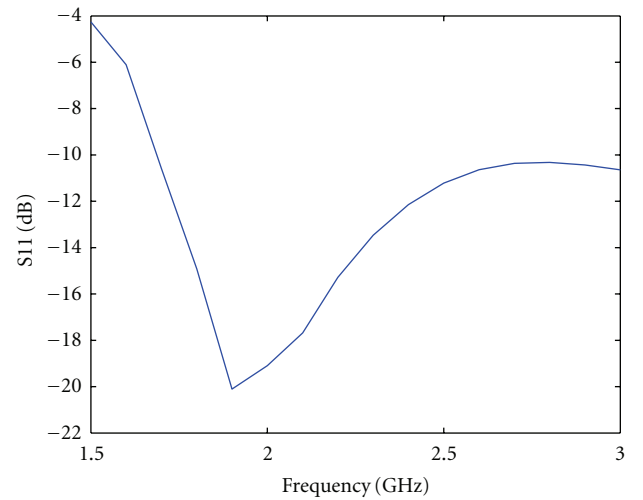
with a gap G_s . The detailed antenna dimensions are listed in Table 1.

In order to achieve a compact multiband antenna, a novel structure is proposed in this paper. The multiband characteristic is obtained by loading a meandering microstrip line to an ultra-wideband monopole element. Figure 2 shows the monopole antenna without microstrip line loaded and the return loss of this antenna. It can be seen that this kind of monopole antenna has ultra-wideband characteristics covering from 1700 MHz to 2900 MHz frequency band. However, only the monopole antenna cannot cover the LTE 700 MHz band. Then a meandering microstrip line is loaded. As shown in Figure 3 the current distribution at 750 MHz reveals the resonance at LTE 700 MHz band.

In addition to the traditional antenna parameters, such as gain, radiation pattern, and reflection coefficients, new parameters and aspects have to be included in the design for MIMO systems. Mutual coupling between antenna elements is a key factor to achieve high antenna performance in the MIMO antenna configuration. For a low mutual coupling, antennas must be far away from each other. But the space for the internal antenna is not enough to obtain low correlation and mutual coupling. In this paper we present a structure for the MIMO antenna elements, in which the identical two antenna elements are orthogonally placed. Then the two antenna elements have orthogonal polarization which



(a) Structure



(b) S11 results

FIGURE 2: The structure and return loss of the ultra-wideband monopole antenna.

can reduce the mutual coupling between the two antennas. Figure 4 shows the simulated 3D radiation patterns of the two antenna elements. It can be seen that the two antenna elements have orthogonal polarizations.

3. Simulation and Measurement Results

To validate the above analysis, the proposed structure is simulated in HFSS and measured in an anechoic chamber. A prototype of the proposed antenna as shown in Figure 5 was fabricated and tested, and the detailed dimensions can be found in Table 1. Figure 6 shows the simulated and measured return loss, which agree well. The measured -10 dB return loss bandwidths are 745–790 MHz and 1700–3000 MHz, which cover the whole LTE bands. The mutual coupling between the two ports is less than -13 dB across the common bandwidth, as shown in Figure 7.

Figures 8 and 9 show the radiation patterns of the antenna 1 and the antenna 2 at 760 MHz, 1750 MHz, 2150 MHz,

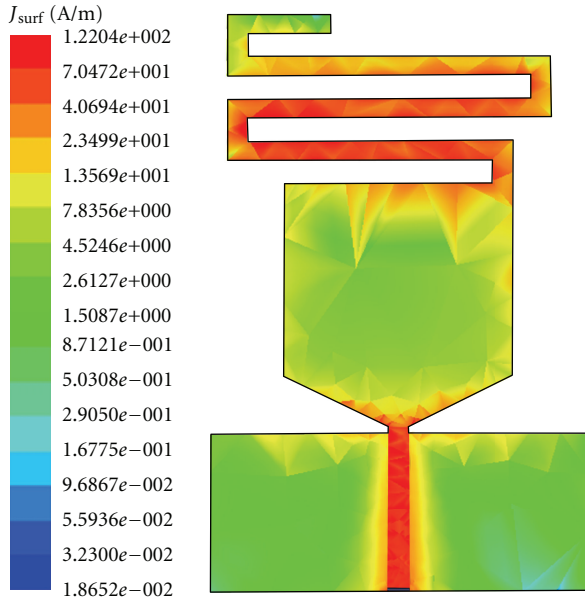


FIGURE 3: Current distribution at 750 MHz.

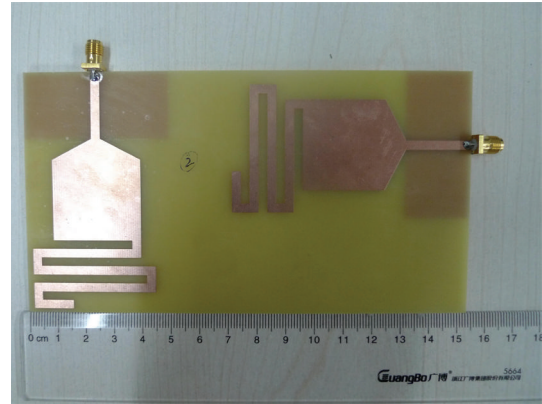
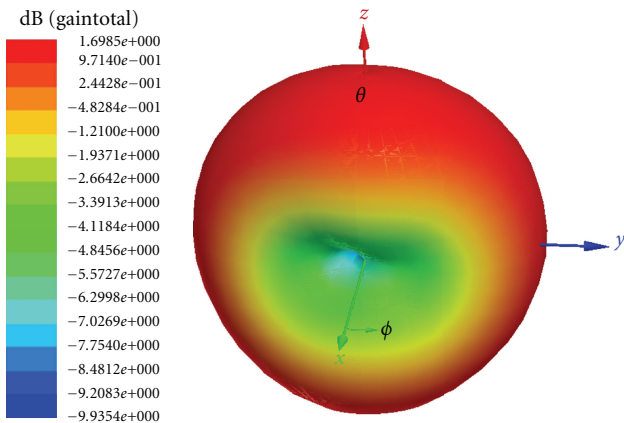
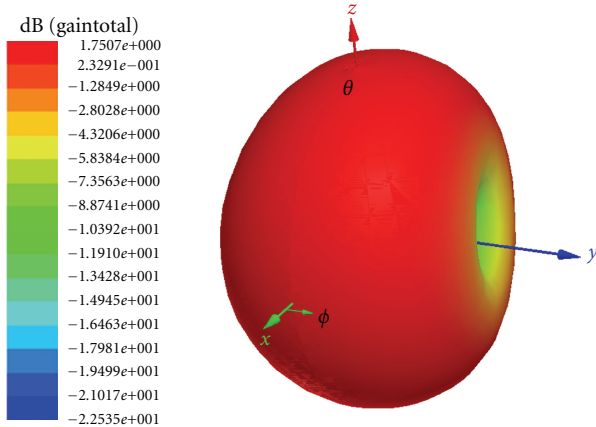


FIGURE 5: Photograph of the fabricated antenna.



(a)



(b)

FIGURE 4: 3D radiation patterns of the two antenna elements.

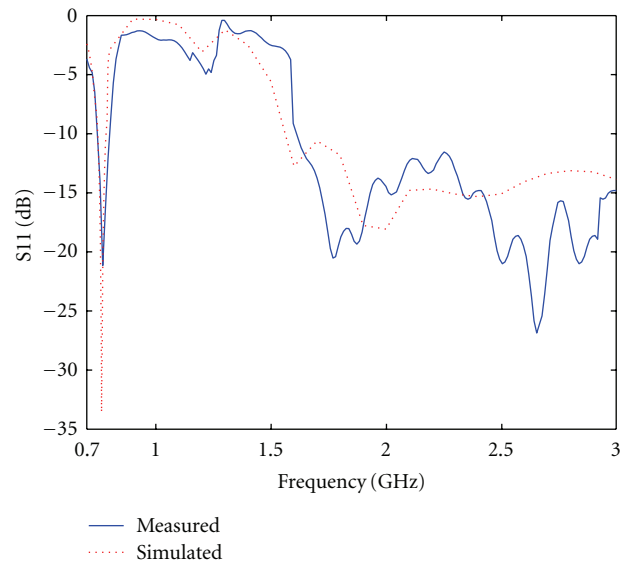


FIGURE 6: Simulated and measured S11 of the proposed antenna.

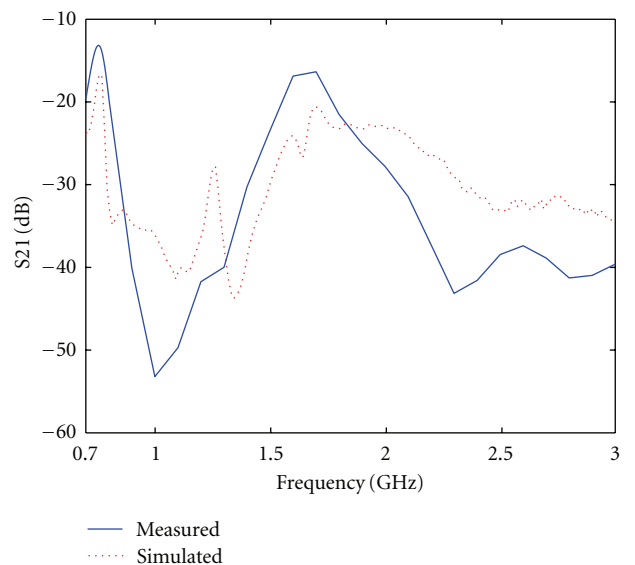


FIGURE 7: Simulated and measured S21 of the proposed antenna.

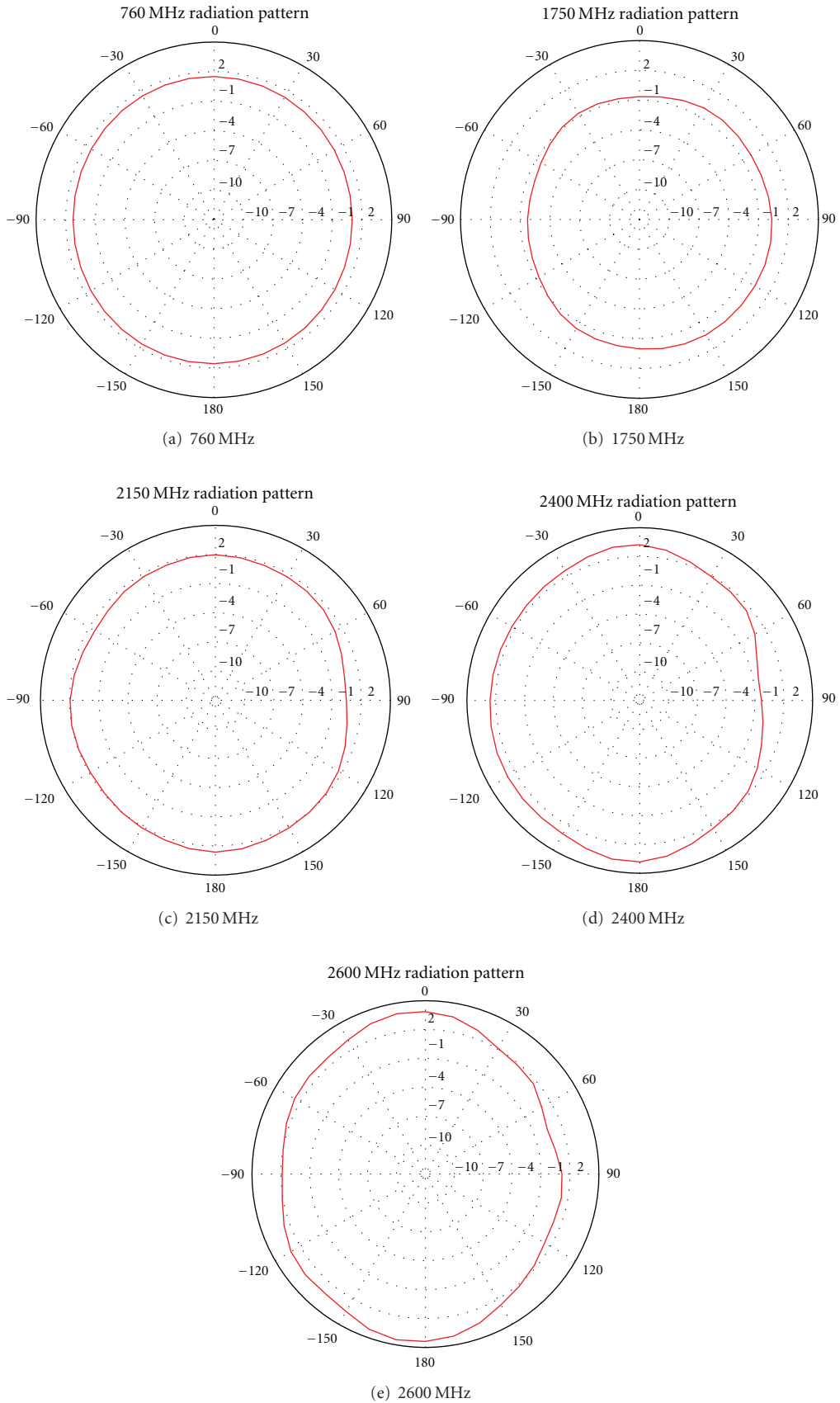


FIGURE 8: Radiation patterns of antenna 1 in x - z plane.

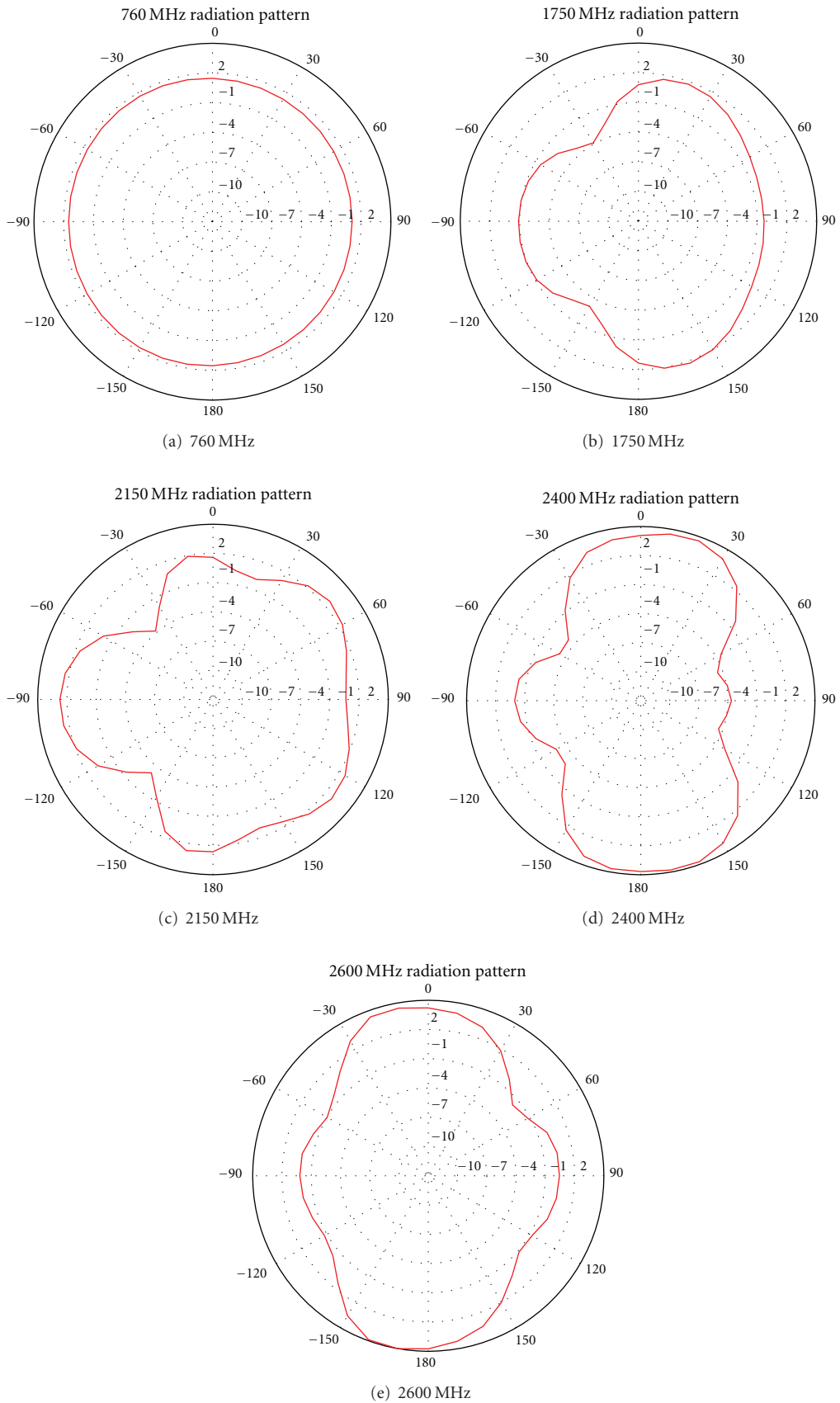


FIGURE 9: Radiation patterns of antenna 2 in y - z plane.

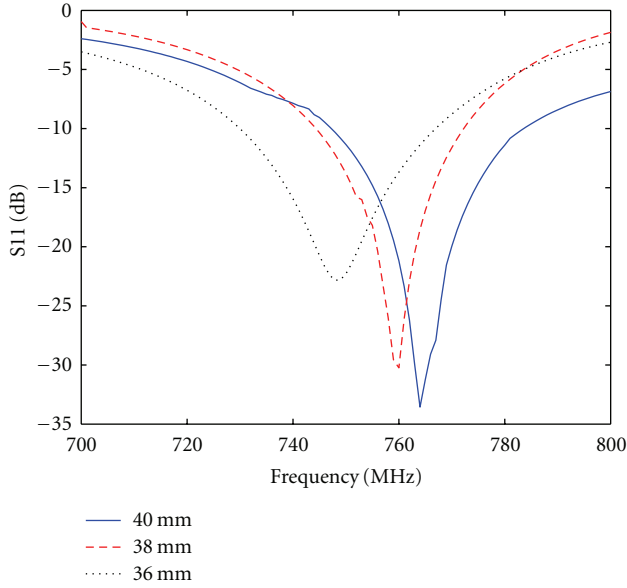


FIGURE 10: S11 of the antenna with different L_{strip} .

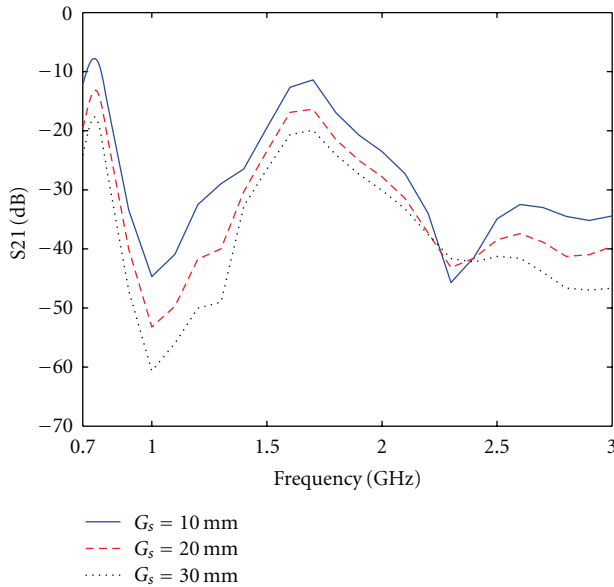


FIGURE 11: S21 of the antenna with different G_s .

2400 MHz, and 2600 MHz. The antenna 1 has an omnidirectional vertically polarized pattern in x - z plane and the antenna 2 generates horizontally polarized radiation in y - z plane. The omnidirectional patterns can enhance and increase the channel capacity [6]. Thus the proposed antenna is more attractive for MIMO application.

4. Parameter Study

For the purpose of optimized performance, parametric studies of the dimensions of the antenna structure are carried out. First, we analyze the length of the meandering microstrip

line. As presented in Figure 10, the resonant frequency at LTE 700 of the antenna is changeable. The resonant frequency goes up when the length is longer and goes down when the length is smaller.

The isolation between two polarizations will be affected by the dimension of spacing G_s . In principle, the larger the spacing is, the lower of the mutual coupling will be. As shown in Figure 11, the spacing is changed from 10 mm to 30 mm and the mutual coupling is from below -9 dB to below -19 dB.

5. Conclusion

In this paper a design of multiband planar monopole antenna for LTE MIMO system has been proposed and implemented. Simulated and measured results showed that the antenna can cover five LTE frequency bands and has high isolation. The proposed antenna will provide better propagation channel and enhance the capacity of MIMO system.

Acknowledgment

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