Study on Dual-Band Four-Port MIMO Antenna with High Isolation

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Abstract:

A dual-band four-port MIMO antenna with high isolation is proposed in this paper. The two operating bands of the MIMO antenna were located at 3.5-GHz and 4.9-GHz. The antenna was composed of four ring monopole elements with microstrip-fed, which were symmetrical placed on the substrate of the antenna. Meanwhile, the rectangle slot, the protuberance, and the modified serpentine structure were introduced into the antenna to enhance the isolation between each monopole element. This letter reports the processes of the design and the experimental test for this MIMO antenna. From the experimental results, less than -15dB isolation were obtained within the operation bandwidth, which is in accordance with the simulation results.

Key words: Dual-band, Four-port, High isolation, MIMO

Ⅰ. Introduction:

Now, the next generation of communication technology 5G has entered the standard-setting stage. No doubt, 5G will give users a new experience, it has 10 times faster than 4G transmission rate. This puts forward a new requirement for the antenna system. In 5G communication, the key to achieve high-speed rate is millimeter wave and beam forming technology, but the traditional antenna is obviously unable to meet this demand. Although the future 5G mobile communication will vigorously develop millimeter wave band, but would not abandon the low band, of which the more likely bands are 3.5GHz and 4.9GHz. Meanwhile MIMO antenna uses multiple space channels to transmit and receive data, and MIMO technology can improve the capacity of the channel, so MIMO technology will be widely used in 5G mobile networks [2], [3]. Isolation of antenna units is an important parameter in the MIMO system. How to reduce the mutual coupling and improve the isolation is an urgent problem in MIMO antenna system.

The ways to improve the isolation are as follows: cutting slots on the ground plane or adding extra mutual coupling structure. For example, three slots were cut on the ground plane, serving as resonators, to reduce mutual coupling [4]. A tree-like structure was added between the two elements to enhance isolation [5].

In this paper, we proposed four-port MIMO antenna. Each port is connected to a ring patch via a microstrip line. Both cutting slots and adding extra mutual coupling structure were used between the antenna units. The simulation results show that designed antenna cover the bands of 3.2-3.7 GHz and 4.2-5.2 GHz. The measured isolation of less than -16dB can be achieved.

Ⅱ. Antenna design:

The proposed four-port MIMO antenna was shown in Fig.1, which was printed on a FR-4 substrate, of which thickness is 1.6mm, permittivity is 4.4, and loss tangent is 0.018. By optimizing the design, the final size of the antenna was 70 mm x 90 mm. The antenna consisted of four monopole elements with a ring shape element symmetrically printed on one side of the substrate, and a partial ground-plane was on the other side of the substrate as shown in Fig.1. Each monopole element was composed of one microstrip fed line and one ring.

In order to impedance matching, the dimensions of the antenna were optimized by using HFSS software, and the structure parameters are shown in Table 1. The rectangle slot, the protuberance, and the modified serpentine structure were introduced into the MIMO antenna to reduce mutual coupling.

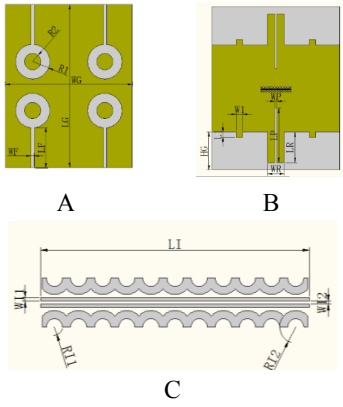
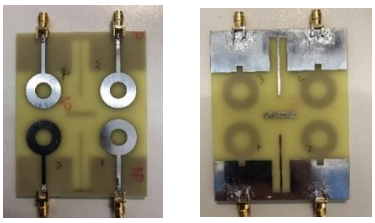


Fig.1 Geometry of the proposed antenna (A) top view and (B) bottom view and (C) serpentine structure

Table 1 Dimensions of the proposed antenna (mm)

WG=70	LG=90	WF=2	LF=22
R2=4.5	R1=9.5	HG=21.1	W1=3.5
L1=3	WR=9.2	LR=17	WP=1
LP=33	RI2=1	LI=16.7	RI1=0.5
WI1=WI2=0.2			



A B

Fig.2 Prototyped antenna (A)top view and (B)bottom view

Ⅲ. Results and discussions:

Firstly, based on the calculations above, the entire antenna were fabricated. Fig.2 shows the photograph of the four-port MIMO antenna. The comparisons of S-parameters of the proposed MIMO antenna between the simulation results and experimental test results were shown in Fig.3. The simulated S11 is less than -10dB from 3.3GHz to 3.7GHz for the lower band and from 4.2GHz to 5.2GHz for the higher band. In both bands, the mutual coupling coefficients of the antenna elements, S21 S31 and S41 were below -15dB. The experimental test was done using the vector network analyzer (VNA) Agilent Technologies, E8363B, and the test results were also labeled in Fig.3 in order to compare with the simulation results. It can be seen from Fig.3 that the measured resonances for the two operating frequency bands moves to the lower band slightly. It can be explained as follows. In the simulation analysis, no feeding cable was considered, but a coaxial feeding cable was always needed to connect the antenna to the test system when the antenna was measured using VNA. The introduction of coaxial cable will change the distribution of current on the surface of the antenna, thus resulting in the change of S-parameter.

The comparisons of radiation patterns between the measured results and simulated results at both 3.5GHz and 4.9GHz were shown in Fig.4. Good accordance between the simulation and experimental test results indicates a reasonable design and accurate fabrication.

Ⅳ. Conclusion:

The 5G MIMO antenna, consisting of four ring monopole elements, was reported in this letter. The design, fabrication and experimental test for this novel antenna were carried out. The experimental test results were well agreed with the simulation results, both which can obtain less than -15dB isolation within the operation bandwidth. These results demonstrate the proposed antenna in this letter is a good candidate for future 5G mobile communication.

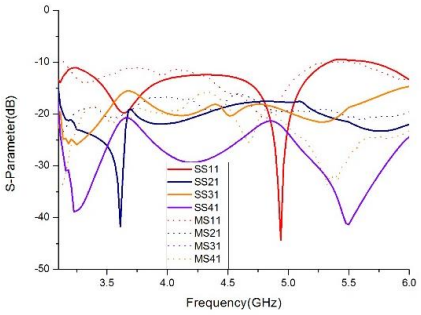
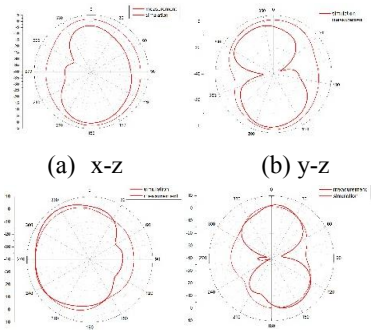


Fig.3 Simulated (SS11-41) and measured (MS11-41) return loss



(a) x-z (b) y-z

(c) x-z (d) y-z

Fig.4 Radiation patterns 3.5GHz (a & b) and 4.9 GHz (c & d)

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