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Retraction

Retracted: A Design of Double Broadband MIMO Antenna

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The article titled "A Design of Double Broadband MIMO Antenna" [1] has been retracted at the request of the authors. The paper was found to include incorrect figures and data, affecting the validity of the conclusions.

References

[1] Y. Geng, R. Ma, B. Chen, and W. Zhang, "A design of double broadband MIMO antenna," *International Journal of Antennas and Propagation*, vol. 2015, Article ID 952137, 6 pages, 2015.

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Research Article

A Design of Double Broadband MIMO Antenna

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The MIMO antenna applied to LTE mobile system should be miniaturization and can work in the current communication frequency band; isolation between each antenna unit also should be good so as to reduce loss of radio wave energy and improve the antenna performance of the MIMO system. This paper puts forward the design scheme of a broadband MIMO double antenna. And the design of antenna unit and debugging and related technical measures, such as bending antenna bracket, are both presented; the integration design of high isolation of ultra broadband MIMO antenna is realized on the plate with the volume of $100 \times 52 \times 0.8\ \mathrm{mm}^3$; antenna working bands are 698 MHz~960 MHz and 1710 MHz~2700 MHz; in the whole spectrum, the 10 dB of port isolation can be basically achieved; in low frequency band, the isolation degree of antenna port can reach 12 dB.

1. Introduction

Now, the mobile MIMO antenna system requires that antenna unit should have the characteristics such as broadband and working in the epidemic communication frequency band; miniaturization, it should have small size and be easy to be carried with; it should prolong the using time as long as possible and also be convenient for the different users [1–3].

Between each of the antenna units, the antenna should have the low mutual coupling and high isolation degree; thus, it can reduce the energy coupling between each of them and make more energy be radiated or received through the antenna unit effectively; the low correlation is also necessary, which can increase diversity effect and improve the communication ability of the MIMO system.

As for the antenna designed for the MIMO system, it should firstly satisfy the system demands of working bandwidth, the efficiency, directivity and gain of the antenna unit, and so forth. And then the correlation between each of the antenna unit signals or port isolation features should also be considered. Finally, performance of the whole system can be assessed combined with the integration design and the design features [4–8].

Now, the mobile MIMO antenna system requires that antenna units have characteristics such as broadband characteristics, and it can work at communication frequency; it should be miniaturizated and be in small size and be easy to be carried out; it should also have high efficiency and prolong the lifetime of the mobile terminal single and be convenient for the user.

Among the antenna units, it requires low mutual coupling and high isolation, and it should reduce the energy coupling between each of them. The more energy can be radiated or received effectively through the antenna; low correlation can increase diversity effect and improve the communication ability of the MIMO system [5, 7, 9].

2. Design of Broadband MIMO Antenna

Double antenna layout description is as follows: feed point and short-circuit point are placed along the long sides of the PCB (in the x direction), two antennas are located along the short side of PCB (in the y direction) distribution, and geometric relationship between two antennas presents mirror symmetry parallel in y direction. The antenna size is $15 \times 46\ \mathrm{mm}^2$, on the right side of the antenna is the feeder, and the antenna [2] is connected with 50-ohm matching load just as shown in Figure 1.

As the developments of antenna processing technology, it makes the antenna's built-in integration easy. But as physical restrictions on the size of antenna and mobile phone on the floor, antenna of mobile phone is a kind of electrically

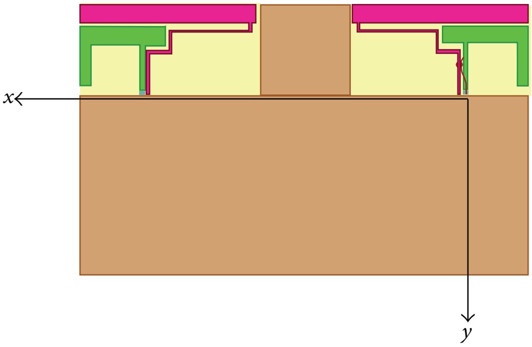

Figure 1: Antenna structure diagram.

small antenna, which has high Q value. The traditional antenna in seeking miniaturization but it is difficult to realize broadband performance [10, 11]. In addition, the multiple antennas are put in the narrow space; the low frequency and high frequency scope of antenna unit are within other antenna near-field areas, and it has strong coupling; it is difficult to achieve good port isolation. Handset antenna design with driven and parasitic elements has been shown to be useful for multiband operation [12].

Therefore, the design of ultra broadband mobile phone antenna should be made from two aspects: under a given size, how to realize the broadband single antenna design; when multiple antennas are at work, how to reduce the coupling between the antenna units, improve the degree of isolation between antennas ports, and reduce the correlation between the antenna signals. The bandwidth of the low frequency part and isolation degree are difficult to be achieved; they are the key of the research work; the design of the high frequency part of the has low difficulty. In the paper, it combines with the characteristics of the mobile terminal, evaluates the advantages and disadvantages of each technology's measures, and extracts more effective ways of ultra broadband mobile phone antenna design [13].

Coupling feed method, it usually adopts aperture coupling feed; it can increase the antenna input impedance of the capacity component; radiating element is connected with "ground"; it can add the weight of inductive component, and then it would produce new resonance points; it will help in broadband antenna tuning. The general methods to produce the multiple resonances of antenna are as follows.

2.1. Changing Structure of the Floor. "Ground" is a relative concept; it is used to describe the zero point of voltage. In mobile phone within its working frequency band, strictly speaking, there is no real sense of "ground"; the introduction of the concept of "ground" can help us better understand the working principle of antenna. K. Fuj imoto in 1968 proposed that antenna floor will also participate in the energy radiation. Feeder cables are connected with one end of the antenna; the other end is connected with the "floor," due to the radio frequency electric current flows through the antenna and floor, so we can look at antenna and the floor as an asymmetric dipole. Therefore, through changing the structure of the floor, reducing floor current, it can improve the antenna matching effects and expand the working bandwidth.

2.2. The Structure of the Coupling Feed Plus Short Circuit. Any form of antenna is made by feeder part, radiating element, matching network, bracket, and so forth; the design of feed network is particularly important. While the coupling feed plus short-circuit structure is the widely used structure, its design principle is very clear; the improving effect of bandwidth is obvious. We usually adopt aperture feeding method; it can increase the antenna input impedance of the capacity component; radiation unit is connected with short circuit, and it increased the inductance component and then produced new resonance points; it will help in the tuning of broadband antenna.

2.3. Adding Integration Components. Antenna loading is a kind of traditional methods of broadening matching bandwidth; it can load pure resistance, inductance, capacitance, or the complex impedance. For the mobile phone antenna, it generally uses inductive or capacitive load. It is because, among the input impedance of ultrawide band antenna, the resistance component is small, and while reactive component is very big, it can be made up through introducing centralized components; on the other hand, because pure resistance loss is too big, it can reduce the radiation efficiency of the antenna. Inductance is a DC resistance component of communication, which is often used in the low frequency part of the tune; in contrast, capacitance is commonly used in the high frequency part of the tune.

2.4. Adding Parasitic Unit. Adding reasonable parasitic unit around the antenna can be seen as a way of using the near-field antenna tuning of coupling; it can reduce the dielectric substrate stray field outside and can help to reduce coupling of other electromagnetic devices of antenna, and it can improve overall electromagnetic compatibility.

This scheme takes advantages of the technical measures such as plate bending, inductance load, and antenna support adding; the integral design of the antenna layout schemes is selected in advance. When the reference standing wave is less than 5 dB, antenna unit can work in the whole frequency band; port isolation can achieve 12 dB; ECC (Envelope Correlation Coefficient) will be smaller than 0.15; although the body thickness is 2 mm, it is relatively thick, but the antenna's radiation efficiency can reach 68%. The photo of the antenna is as shown in Figure 2.

3. Main Design Parameters

The antenna volume shall not exceed $105 \times 58 \times 13.5\,\text{mm}^3$; dielectric constant is 3; tangent value of loss angle is 0.06. The plate volume is $100 \times 52 \times 0.8\,\text{mm}^3$; dielectric substrate constant is 4.4; the tangent value of loss angle is 0.02.

Single antenna volume shall not exceed $15 \times 52 \times 5\,\text{mm}^3$; reference port of standing wave is 5 dB or 6 dB; working band is in all frequency bands, namely, 698~960 MHz and 1710~2700 MHz; the antenna's radiation efficiency at low frequency

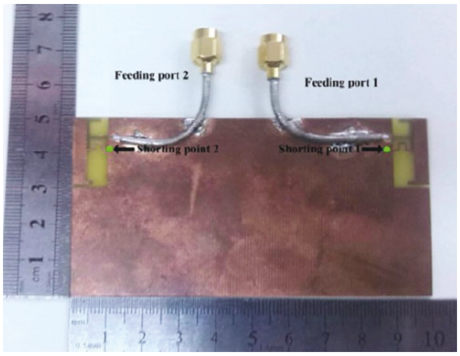

Figure 2: Photo of the antenna.

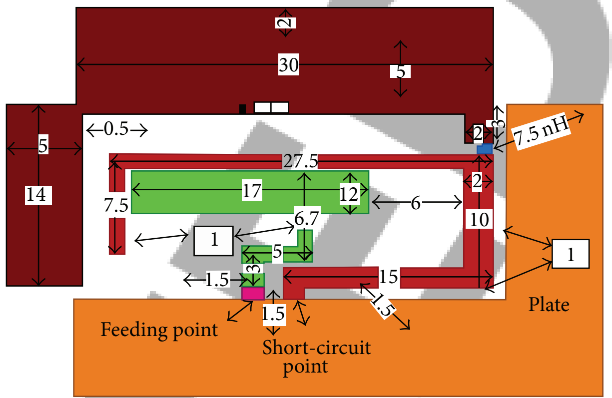

Figure 3: Single antenna structure diagram.

part shall not be less than 40%; in the high frequency part, it shall not be less than 55%; the gain is less than 3 dB. Requirements of isolation is that in the whole frequency band $S_{12} < -8$ dB. Requirements of ECC is that in low frequency part it should be less than 0.5, and in the high frequency part it should be less than 0.3.

4. Design Principle

It can be seen that the size of antenna is very small; it also requires that the antenna can work at all frequencies; port isolation degree should also be better. Combined with the design experience of phone antenna, reasonable designs of antenna unit and antenna layout are the first step. As for the antenna unit, in the paper, it adopts the aperture coupled feeding structure and makes combination of concentrated component loading and short-circuit technology, so it will take up less space; in the layout of the double antenna, it should adopt the layout that does not shorten the length of the “ground,” in order to get good port isolation effect. If it just depends on the design of the antenna itself, it is difficult to meet the design requirements, so it must be combined with auxiliary measures, such as changing structure of the antenna plate, adding parasitic unit (antenna bracket), and other auxiliary measures. In addition, in order to reduce the design difficulty and improve the efficiency of design, the modeling process should be together with the simulation design.

4.1. Simulations of Single Antenna. According to the layout, it selects the antenna’s relative position on the plate, through the optimized design of antenna unit and combination with the technical measures, such as antenna bracket; it also prolongs plate to meet the design requirements of the single antenna; the detailed dimensions are as shown in Figure 3. Antenna occupied volume is $15 \times 31 \times 5\,mm^3$, the volume of plate is $100 \times 52 \times 0.8\,mm^3$, the whole volume is $105 \times 58 \times 13\,mm^3$, thickness of plate is 2 mm from up to down, and thickness from left to right side is 1 mm.

Current of antenna is fed from the feed point unit; through the aperture, it is coupled into the current radiation unit; finally, it reaches short-circuit point. Resonant modes are excited in the frequency of 1.69 GHz and 2.28 GHz; it

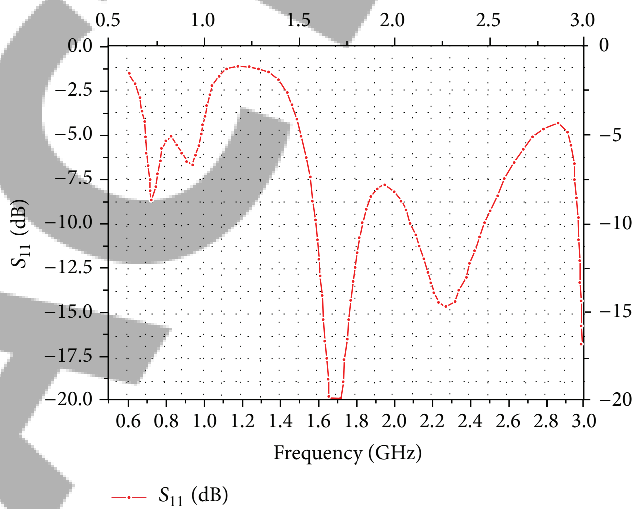

Figure 4: S parameters of single antenna.

covers from 1710 MHz to 2700 MHz. Through loading the 7.5 nH concentration components, it can effectively tune the input impedance of 698 MHz~960 MHz part; the antenna can work in resonant modes on the frequency of 0.74 GHz and 0.93 GHz.

Simulations of reflection loss and radiation efficiency are shown in Figures 4 and 5. When standing wave is less than 5 dB, the antenna can work in the whole frequency band; although the casing material loss is bigger and due to the high efficiency of port matching, radiation efficiency in the whole frequency band still can reach more than 68%, which meet requirements of the design.

Figure 4 shows the S_{11} of single antenna working in different environment. Ref1, ref2, ref3, and ref4, respectively, represent the situations that there is no antenna bracket, there are no antenna brackets and floor of the bend, there is no bending of the floor, and there is no antenna casing.

It can be seen from the figure that, in ref1, antenna bracket shows little impact on S_{11}; it is consistent with design purpose, but it is true that the width of the bracket will affect S_{11}; in addition, it can play a function of fixed antennas. In ref2, it only consists of chassis; the impedance matching conditions

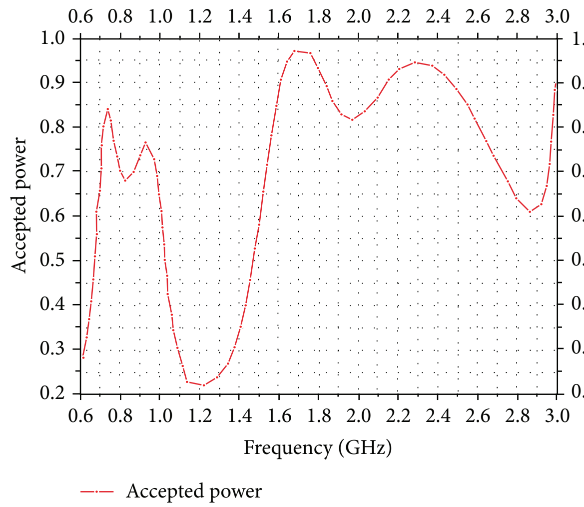

Figure 5: Radiation efficiency of the antenna.

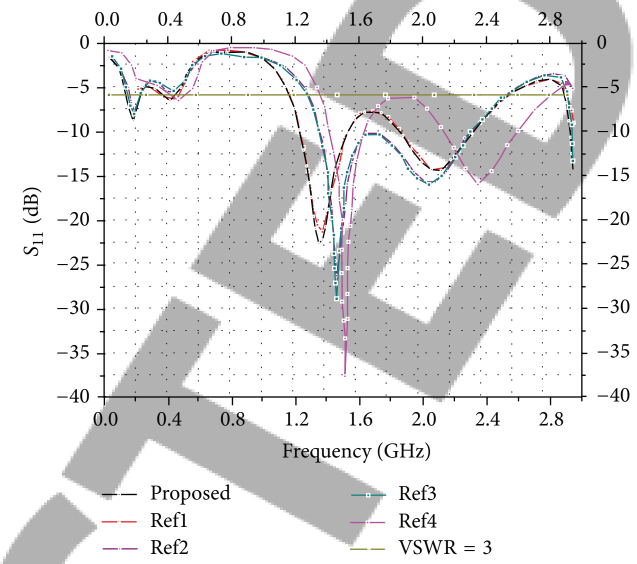

Figure 6: Value of S_{11} under the different environment.

are worsened near frequency of 0.825 GHz, so it cannot meet the design requirements; through making contrast with ref3 and ref2, it can be found that the difference of matching condition is little; in ref4, in the low frequency part, the casing has influence on S_{11}; through adding a chassis, lower resonant mode can be stimulated, and it can improve the matching conditions of the antenna; the antenna's radiation is similar to the microstrip antenna. Therefore, through changing the structure reasonably, it can improve the antenna matching effect; the integration of modeling optimization also can reduce the design difficulty.

As the inductance has a smaller effect on high frequency part of the antenna matching, and it is greatly influenced in the low frequency part, in Figure 6, it gives out the influence of inductance L on S_{11} within the frequency of 0.6 GHz~1 GHz. In the low frequency, resonant mode of L is relatively sensitive, through optimizing of $L = 7.5$ nH; when $S_{11} < 5$ dB, it can cover the low frequency part.

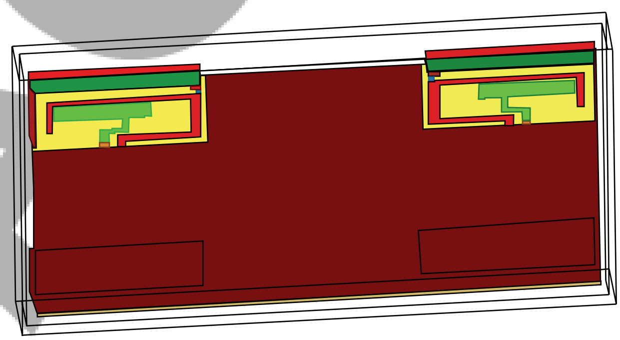

Figure 7: Double antenna structure diagram.

4.2. Simulation of Double Antenna. In the single antenna, when impedance matching and radiation efficiency all meet the design, the antenna units present axisymmetric distribution. Antenna unit structure and S parameters are as shown in Figures 7 and 8, respectively.

Through Figure 8, we can see that, compared with single antenna, the work resonant mode of double antenna is not changed and just its match status is changed; matching status in the frequency point 0.74 GHz is improved, while matching status is deteriorated in 1.69 GHz, but it still meets the design requirements. The degree of isolation of antenna ports in the whole spectrum is maintained at the levels of 10 dB. In the design scheme, the isolation in low frequency part can reach 12 dB. Figure 9 shows the radiation efficiency of the antenna unit; within the whole frequency band, the efficiency of the antenna can be larger than 62%, so it can meet the design requirements.

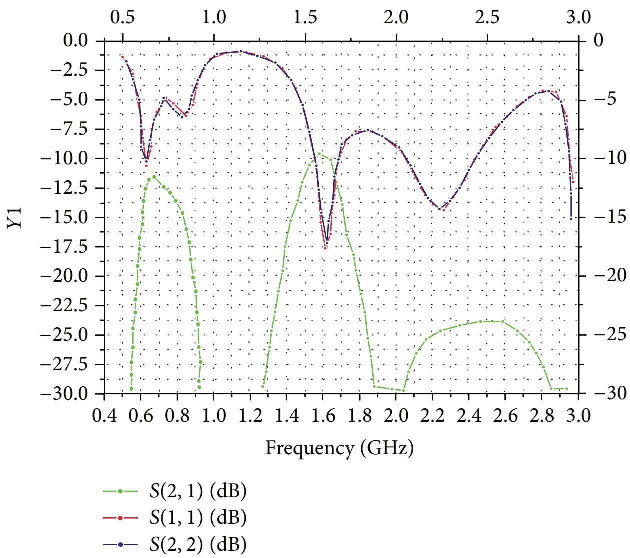

Figure 8: S parameter of the design scheme.

Figure 10 shows the port isolation degree under different conditions. Ref1 and ref2, respectively, represent

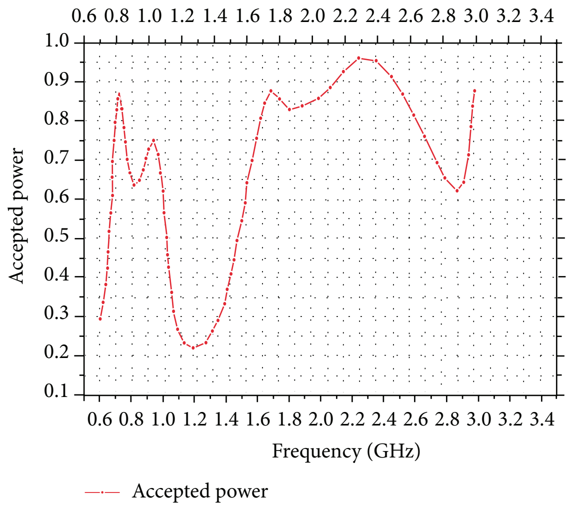

Figure 9: The radiation efficiency curve.

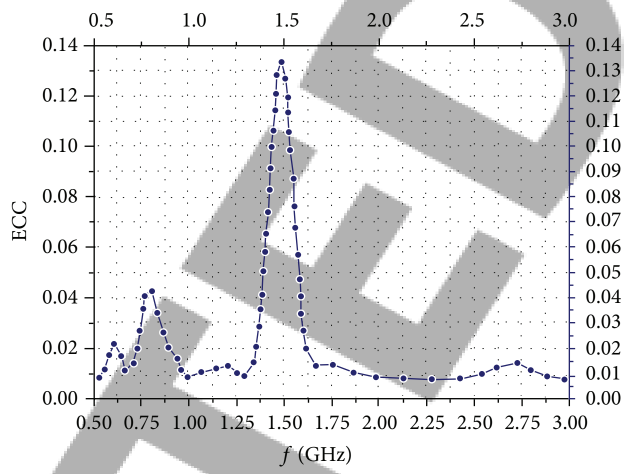

Figure 11: ECC of correlation coefficient envelope.

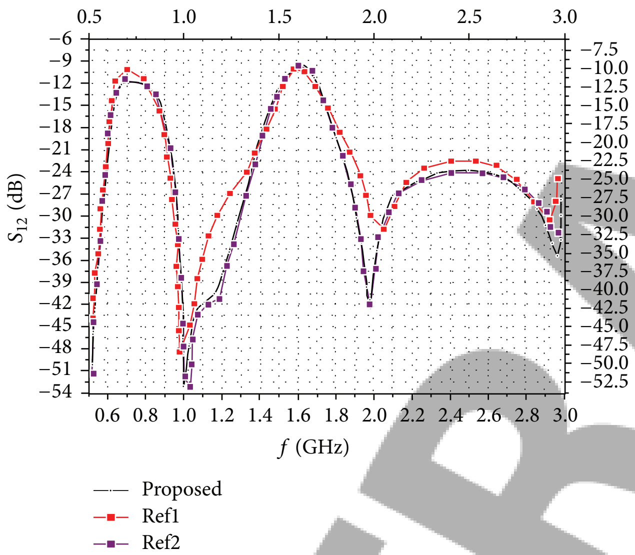

Figure 10: The radiation efficiency curve.

the design without bending the plate and design without antenna bracket. Because the bending of plate can improve the impedance matching conditions near the frequency 0.825 GHz, combined with the symmetry of the antenna unit, isolation degree is relatively poor near frequency 0.825 GHz, but it still can meet the requirements of design.

The related type of ECC is calculated as shown in Figure 11. In the whole frequency band, the values of the ECC are less than 0.15.

5. Conclusion

In the paper, in the space whose volume is $105 \times 58 \times 13\ \text{mm}^3$, it designs a broadband MIMO antenna which can work in the whole spectrum; the bending height plate is 8 mm. Within the spectrum, port isolation of antenna can achieve 10 dB; in low frequency part, it can reach 12 dB.

In the design, it highlights the integration design principle of dual antenna and process; as the physical size limitation of design platform, it first gives out antenna unit design and antenna layout scheme; then, it considers the antenna casing and the influence of the support and it decreases the difficulty of design and then uses the bending of the plate to make antenna performance meet the design requirements; finally, the antenna unit can meet the design requirements and the layout is determined; the integral design of the dual antenna is obtained. Although the thickness of the antenna casing is relatively high, the energy loss in the fuselage will be increased, but the overall antenna matching condition is very good; the antenna's radiation efficiency is still high, which can satisfy the design requirements.

Conflict of Interests

The authors declare that there is no conflict of interests.

Acknowledgments

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