Quadruple Feed MIMO Antennas with One Shared Radiator for 5G Mobile Terminals

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***Abstract*—This paper introduces a new type of quadruple-feed MIMO antennas. By optimizing the width and position of the neutralization line in the middle and adjusting the position of the shorting pins on the radiator, the proposed antenna can achieve high isolations between four independent ports. The measured matching bandwidths of all four ports with return losses lower than 10 dB is from 3.3 GHz to 3.6 GHz. Meanwhile, the isolations between each port are higher than 17 dB. The measure results indicate that the proposed antenna can be applied in the 5-th generation communication system.**

***Keywords*—Multiple-Input-Multiple-output (MIMO), mutual coupling, 5-th generation, mobile phone antennas.**

I. Introduction

With the penetration of 4G wireless services, and the advancement in the 5-th generation wireless systems, higher-order MIMO systems are demanded. Four by four MIMO technology is able to improve the transmission rate and quality without sacrificing other performances and without additional bandwidths. The challenge however, lies in the stringent area limitation while realizing so many antennas in a more and more compact mobile terminal, which lead to a difficulty of decreasing the mutual coupling between antenna feeding ports. Thus, a great number of researchers have done many works to solve this problem [1-7]. But most of the existing methods are either complex or difficult to be extended to more antennas.

This paper introduces a novel MIMO antenna system with four input ports. The proposed antenna has a compact structure, and the isolation between each port is high enough. More importantly, no extra circuits or structures are needed. The detail design procedure will be provided in the following section.

II. ANTENNA DESIGN AND ANALYSIS

The geometry of the proposed antenna is shown in Fig.1, and the dimensions are also listed in Table 1. This antenna is printed on FR-4 substrate with the dielectric constant of 4.4 and loss tangent of 0.02.

The design procedure starts by designing two dual feed antenna systems (Port1 & Port2; Port3 & Port4) using the method well illustrated in [8]. The position of feeding and shorting pins have been carefully chosen, in order to realize orthogonal radiation modes.

After two dual feed antennas are designed, they are put side by side as shown in Fig. 1. To further increase the isolation between Port 2 and Port 3, a neutralization line is designed. The isolation between Port 2 and Port 3 can be improved by optimizing the length and the width of this line.

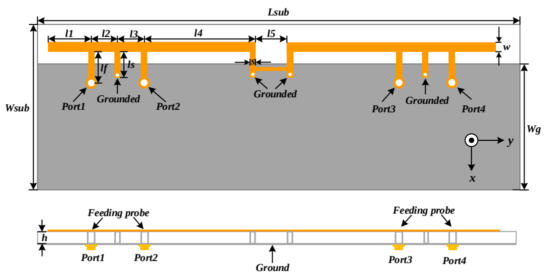

Fig.1 The geometry of the proposed antenna.

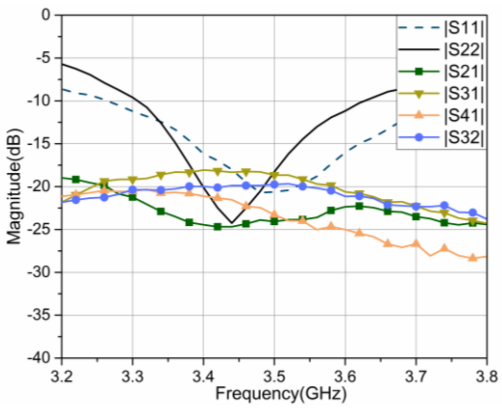

Fig.2 The measured S-parameters of the proposed antenna.

TABLE I
DIMENSIONS OF THE PROPOSED ANTENNAS(UNIT:MM)

Variable	l1	l2	l3
Value	12.45	6.3	7
Variable	lf	ls	s
Value	8.5	7	1.5
Variable	l4	l5	w
Value	30.25	8.5	2.5
Variable	Wsub	Wg	h
Value	35	24	0.8
Variable	Lsub		
Value	130		

The measured S-parameters are shown in Fig2. The return losses of each port are more than 10dB from 3.3 GHz to 3.6 GHz. And the port isolations are more than 17 dB. Obviously, the proposed antenna with simple structure can normally operate from 3.3 GHz to 3.6 GHz. This covers one of the most popular 5-th generation mobile communication band.

To explain the working mechanism of the proposed antenna, the surface-currents while exciting different ports are also plotted in Fig 3. Among these, (a) shows the current when port 1 is excited while other ports are terminated with matched loads, and (b) shows the current when port 2 is fed. Only surface-current for port 1 and port 2 have been given in this paper because of symmetry in the proposed structure.

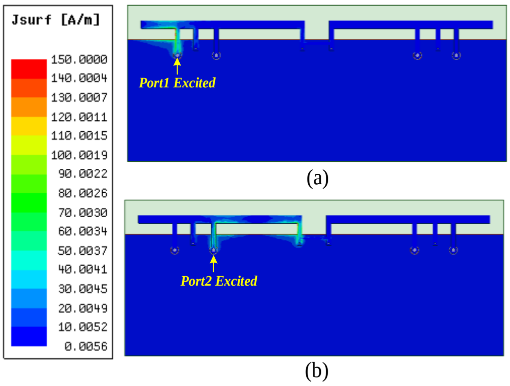

Fig.3 Simulated surface current density of the antenna while feeding Port 1 and Port 2, respectively.

III. PERFORMANCE EVALUATON

The radiation characteristic of the proposed antenna is also analyzed. Fig 4 shows the simulated patterns when port 1 and port 2 are excited respectively.

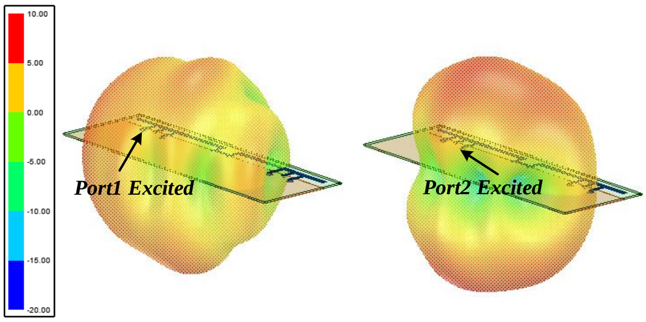

Fig.4 Simulated radiation patterns while Port1 and Port2 are excited, respectively.

One essential parameter for MIMO systems is envelope correlation coefficient (ECC). Fig 5 shows the ECC between ports, and all the values are lower than 0.1, which can meet the demands of MIMO system.

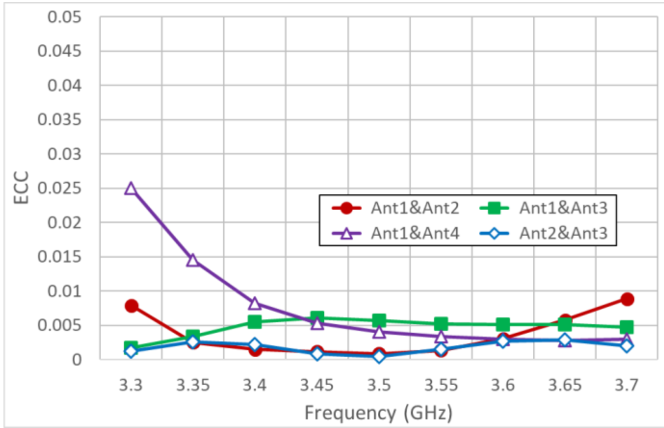

Fig.5 Calculated ECC from simulated radiation patterns.

IV. CONCLUTION

This paper introduces a multi-feed antenna system that supports four MIMO operation at the 5G wireless communication band. The antenna has a simple structure with good performance in isolation, efficiency as well as correlation. It also has the potential to be applied to a 5G metal frame phone. By finding the proper feeding and shorting position on the metal frame and by using neutralization lines at proper locations, the metal frame itself can support multiple well isolated antenna ports. Relevant work has been done and the results will be reported later.

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