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Eight-Ports Dual-Band MIMO Antenna for 5G Mobile Handset Terminals

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Abstract

This article present the design of a dual-band eight-element MIMO antenna that works at frequencies of 2.4 Ghz and 5 Ghz respectively. The isolated antenna is based on the concept of an IFA antenna (inverted F-antenna), which has been located on the side walls of the chassis of a handset platform (four elements on each side). Through the proposed configuration, it has been possible to obtain a very low mutual coupling between the adjacent antennas, these values are less than <-23 dB. On the other hand, it has been possible to achieve multiple radiation patterns with an EEC (Envelop Correlation Coefficient) lower than 0.06.

1 Introduction

Recently in the last years, the antenna design for mobile handset terminals has become one of the most significant challenges for researchers in this field. The limited space to accommodate multiple antennas on the platform, the requirement for high isolation due to their physical proximity to each other, and the challenge of generating multiple beams for fifth-generation wireless communications make necessary the exploration of several alternatives to satisfy these requirements [1, 2].

Some of the designs proposed in previous works have placed multiple antennas very close to each other on a platform; however, the response of the transmission parameters doesn't represent a good isolation characteristic between adjacent radiating elements [3, 4]. Other designs to optimize spaces and achieve very compact structures have been limited in the integration of the number of antennas [5, 6, 7]. Even in some cases, despite achieving low-profile structures, they are only resonant at a single frequency [8, 9].

Therefore, in this paper, the study of an array antenna with 8 elements that operate at 2.4 GHz, and 5 GHz frequencies is presented. The two resonances are generated by two resonant arms that are part of an IFA antenna (Inverted F- antenna) located on the side walls of the chassis of a mobile device. In the next sections, the operation and the results obtained through simulations will be presented.

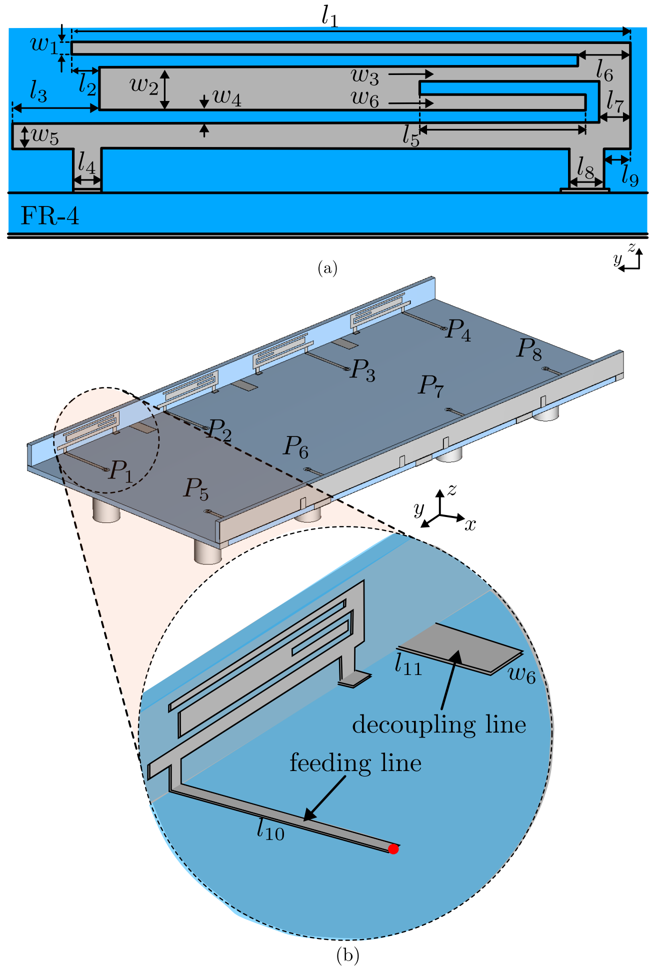

Figure 1. Eight-ports dual-band MIMO proposed antenna. (a) Lateral view of isolated IFA antenna design, (b) 3D view of IFA array antenna integrated at handset platform.

2 Antenna Configuration

The detailed design, parameters, and physical distribution of eight resonant elements integrated into a smartphone platform operating at 2.4 GHz and 5 GHz frequencies are shown in fig. 1. The proposed array antenna in this research has been designed over FR-4 material with dielectric properties ε_r = 4.3, loss tangent δ = 0.006, and height h = 15 mm. The structure of the smartphone platform has dimen-

Table 1. Optimized parameters of the proposed antenna.

Parameter	Value (mm)	Parameter	Value (mm)
w_1	0.45	l_3	3.20
w_2	1.60	l_4	1.00
w_3	0.55	l_5	6.00
w_4	0.45	l_6	1.95
w_5	0.95	l_7	1.15
w_6	0.60	l_8	1.25
w_7	1.75	l_9	1.00
l_1	20.35	l_{10}	15.00
l_2	1.05	l_{11}	1.04

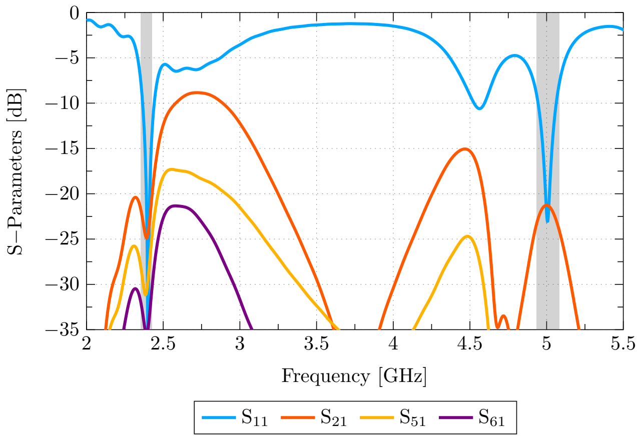

Figure 2. S-parameters of the proposed MIMO antenna.

sions of 150 mm x 70 mm, with two side walls of 150 mm x 7.5 mm, these walls house 4 antennas that work at the two previously described frequencies. The proposed antenna as an isolated element has been inspired by the conventional Inverted F-antenna shape, which is composed of two resonant branches placed horizontally with a common feeding point at the left. To create the array antenna, every single element has been placed on the laterals walls (four on each side), two of the four antennas are located in opposite directions and separated between them at a distance of 15 mm as seen in fig. 1.

To reduce the mutual coupling a parasitic element has been placed between each antenna of the array, this element is shorted circuit with the ground plane (see fig. 1(b)). Each optimized parameter of the proposed single antenna that was used to model in CST Studio Suite has been summarised in table 1

3 Simulated Results

To describe the behavior of the MIMO antenna, a full-wave analysis has been used fig. 2 shows the results of the reflection coefficient of the antenna that is located at the edge of the platform (P_1). The plot shows that the antenna effectively generates two very marked resonances, the first resonance is achieved at 2.4 GHz, and the second is at 5 GHz

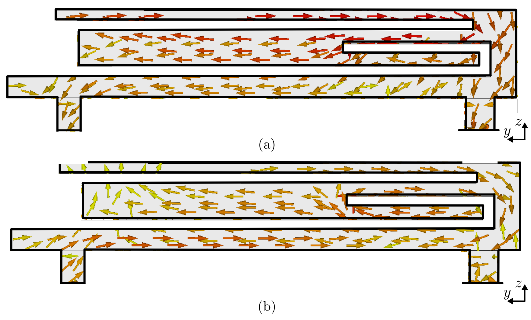

Figure 3. Surface current distribution. (a) At 2.4 Ghz, and (b) at 5 GHz

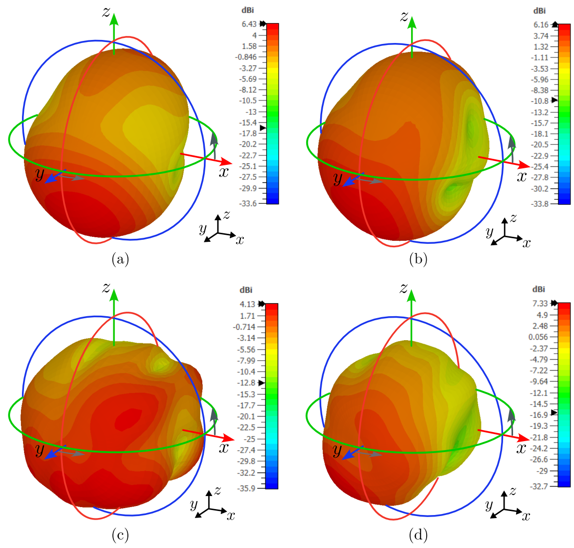

Figure 4. 3D-view of simulated radiation patterns with independent excitation. (a), (b) Antenna 1 at 2.4 GHz and 5 GHz, (c), and (d) Antenna 2 at 2.4 GHz and 5 GHz

as seen in fig. 2. The design of the antenna in the stage before the results were presented produced a very high mutual coupling because the elements are very closed, but inserting a short circuit between the resonant structure and ground plane allows a decrease substantially the coupling values. In fig. 2, it can see the values of the transmission coefficients of antenna 1 concerning its adjacent antennas, the values obtained for all cases are lower than <−23dB.

The representation of the distribution of surface currents that flow over the antenna helps to understand its operation a little better. In fig. 3.(a) and (b), the currents at the frequencies of 2.4 GHz and 5 GHz respectively have been shown. The arm of the antenna located in the central part whose end is folded on itself represents a higher intensity of currents, implying that this part of the structure is generating the first resonance, while the second resonance originates in the arm that is located at the top of the antenna, as is depicted according to the surface current in fig. 3 (b).

Due to the symmetry of the antenna distribution on the handset platform, only the simulated radiation pattern gen-

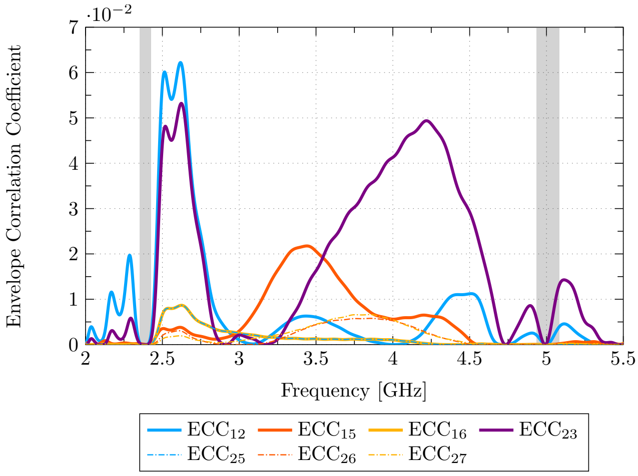

Figure 5. Envelope Correlation Coefficient (ECC) of the proposed MIMO antenna.

erated by antennas 1 and 2 with independent excitation at 2.4 and 5 GHz is represented in fig. 4. The directivity of each of them surpasses 6.16 dBi but with their maximums at different directions. Using different combinations in the in-feeding excitations through power dividers, directional couplers, or software-defined radio (SDR) makes it possible to generate multiple radiation patterns [1].

To quantify the orthogonality that exists between the radiation patterns of adjacent antennas, the Envelope Correlation Coefficient (ECC) is used. Due to the proximity that exists between the elements that are part of the proposed antenna, an analysis has been carried out between the radiation patterns generated by antennas 1−2, 1−5, 1−6, 2−3, 2−5, 2−6, and 2−7 (see fig. 1 (b)). In fig. 5, the ECC values for all the radiation patterns are presented, at the frequencies of 2.4 GHz and 5 GHz, values lower than 0.5 are obtained, being optimal for cell phone applications with MIMO technology, as described in [10].

4 Conclusion

The design of an inverted F antenna has been proposed as a starting element for integration into a mobile terminal platform, managing to integrate 8 elements that resonate at the frequencies of 2.4 and 5GHz, the transmission parameters that describe the mutual coupling have been lower than -23dB. On the other hand, it has been possible to generate multiple radiation patterns using independent power supplies, and great diversity can be generated using the combination of ports at the feeding points. The results of the EEC that describe the orthogonality between adjacent antennas represent values lower than the standard necessary for MIMO technology applications.

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