Multiport broadband 5G MIMO antenna with very high isolation

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***Abstract*—This paper presents a new unidirectional radiating structure with 4 independent radiation patterns, with an isolation of more than 24 dB, and with a bandwidth of 20 %, oriented for use in 5G indoor MIMO base stations. The element can be used as a building block for arrays with a number of antennas of 4x4 or more. The radiating elements are triangular cavities derived from a square cavity with the TMz 11 mode. The 4-port antenna has a very low profile, with a height of 5 mm and the dimensions of the ground plane are less than one wavelength.**

I. Introduction

5G networks have become the biggest development topic in telecommunications in recent years. The 5G bands between 3 and 5 GHz have been deployed for 5G services in many countries such as, 3.4–3.8 GHz in Europe, 3.1–3.55 GHz and 3.7–4.2 GHz in the USA, and 3.3–3.6 and 4.8–4.99 GHz in China [1].

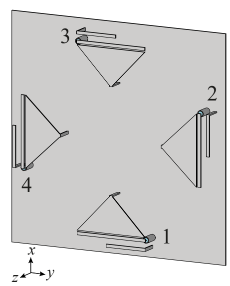
There is a need for MIMO-capable antenna designs with a large number of independent ports for indoor environments. Solutions for sub-6 GHz band are available in dual polarization, with different configurations [2] [3] [4] [5].However, designs for a higher number of ports are scarce.

This communication presents a new antenna design for MIMO capability in indoor environments oriented to the European bands. The requirements are bandwidth, low profile, polarization diversity, unidirectional pattern, isolation between ports and scalability for a larger number of antennas.

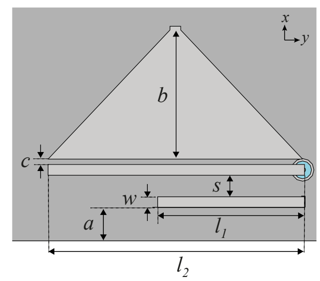
II. Antenna Design

The proposed unit cell consists of 4 triangular shaped cavities, fed capacitively at the hypotenuse of the right-angled triangle and with the opposite vertex connected to ground. The four antennas are placed in a 75 mm square ground plane. This dimension is equivalent to λ at 4 GHz. This unit cell can be repeated to form arrays of a larger number of elements. The design of a configuration with 4 antennas is shown in Fig. 1(a). The details and dimensions of each radiating element are shown in Fig. 1(b) and in Table 1.

The antenna design is derived from a square cavity with the TMz 11 mode whit shorting pin in the center. The field distribution of this cavity is maximum at the edges and minimum at the shorting pin.The four antennas are obtained by cutting this cavity into four equal triangular parts. The dimensions of each resonator are very compact. The criterion for antenna design is that the length of the hypotenuse is at least $\lambda/4$ at the lower frequency of the band. A good bandwidth can be obtained with a low permittivity support dielectric, being air in the proposed design, with a separation between triangle and ground plane of 5 mm. An additional $\lambda/4$ line shorted at one end is included, to increase the bandwidth. The length of this parasitic element is set to cover the maximum frequency of the desired band.



(a)



(b)

Fig. 1. 3D view of proposed antenna element.

TABLE I
OPTIMIZED PARAMETERS OF THE PROPOSED ANTENNA.

Parameter	Value (mm)	Parameter	Value (mm)
a	3	l_1	13.5
b	12	l_2	23.7
c	0.5	w	1
s	2		

III. Analysis and Results of the Proposed Antenna

A study of the resonance modes of the structure has been carried out using the Characteristic Modes Theory (CMA) [6]. The starting point of the design was an antenna made by the authors using capacitively fed SIW cavity technology. [7]. A full-wave analysis was performed with CST studio software. Fig. 2 illustrates the total current distribution obtained from the analysis of the antenna element at the resonant frequency at 3.6 GHz.

From the radiation point of view, the currents responsible for radiation are the ones induced in the ground plane, the edges of the ground plane also contribute to radiation. The radiation patterns are slightly inclined with respect to the broadside direction. The inclination of the radiation patterns follow the directions set by the sides of the square.

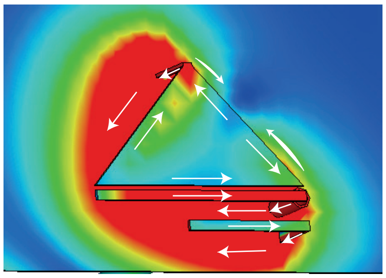


Fig. 2. Current distributions of the proposed antenna element.

A. MIMO Antenna

A full-wave analysis was performed using the integral equation method in the frequency domain to analyze the s-parameters of the structure. The s−parameters from 3 to 4 GHz are presented in Fig. 3. The s_{11} is lower than -10 dB from 3.24 GHz to 3.9 GHz and the mutual coupling between ports is below -24 dB. The values obtained show that the ports are highly decoupled from each other. The bandwidth is greater than 20%.

The antenna has 4 independent radiation patterns, which are shown in Fig. 4. Directivity is 5.77 dBi at 3.6 GHz. The radiation maximum of the radiation patterns is different for each of them, and they point in directions about 45° apart with respect to the z-axis direction. The four radiation patterns correspond to the 4 antenna ports, without the need to add any additional feeding network.

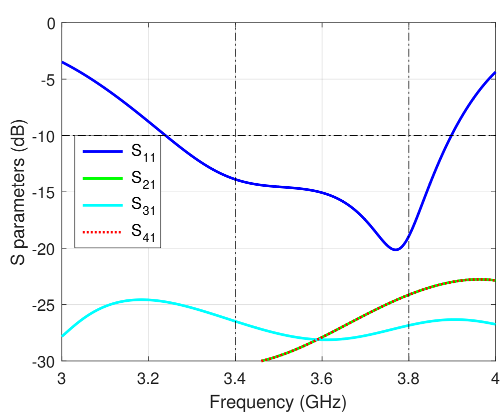


Fig. 3. Simulated S parameter of MIMO antenna.

IV. Conclusions

An antenna has been designed with 4 independent patterns, with an isolation of more than 24 dB and a bandwidth of 20%, covering the European 5G band from 3.4 to 3.8 GHz with return loss of less than 15 dB. The 4-antenna unit cell

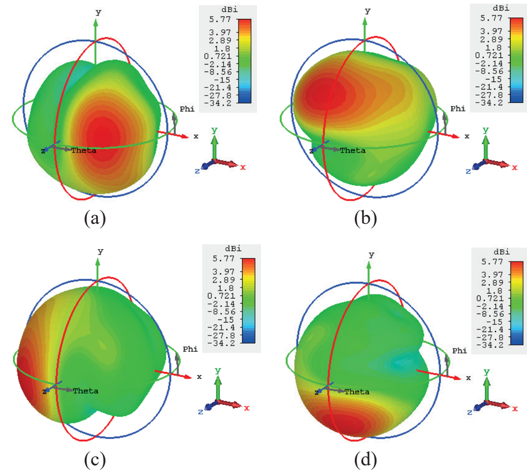


Fig. 4. 3D patterns of MIMO antenna, feeding: (a) Port 1, (b) Port 2,(c) Port 3,(d) Port 4.

can be repeated, and MIMO-capable arrays with a higher number of elements such as 4x4 or 8x8 could be implemented. The bandwidth obtained and the isolation between ports are particularly interesting for 5G indoor base stations.

The final presentation will include measurements of the prototype currently being measured, along with radio channel characterization.

Acknowledgment

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