Dual-Band MIMO Antenna System for Next Generation Smartphone Applications

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Abstract. In this new article, a different model of dual-band MIMO compact antenna array is proposed for the upcoming fifth generation smartphone mobile terminal. The antenna conatins eight antenna elements covering dual frequency rang including 3.18-3.96 GHz and 4.95-5.52 GHz of sub 6 GHz 5G spectrums. The elements are fed by modified Fshaped microstrip feeding lines. Essential characteristics of the suggested model are examined. It proposes adequate S-parameters, suitable isolation, sufficient radiation analysis, and efficiency. At 3.6 GHz the Ant 5 has maximum return loss of -25dB while Ant 7 has maximum return loss of -26dB at 5.2 GHz of the proposed dual band frequency of 5G smartphones.

Keywords: 5G communication, dual-band antenna, smartphone compact antenna array.

1 Introduction

In recent days, as the mobile and communication technology is developed more rapidly so the use of wireless technology and their applications has been increasing very fast as well. This considerable growth in wireless communication is essentially due to the applications of the internet of things (IoT), artificial intelligence and mobile video streaming [1-4]. Because of the astonishing request, the existing wireless communication range is dropping its vacant free space. Fifth-generation cellular phone networking is the recent key answer for the bandwidth and advance progression of wireless communication technologies and the growing demand for cell phone communication structures over the following period until 6G arrives [5-8]. To achieve the high data rate and low latency 5G is the ultimate solution for the wireless communication technology [9-10].

The multiple-input multiple-output (MIMO) Compact antenna array which involves a bunch of antennas in the receiver and transmitter is a key for this 5G technology [11-14]. To provide the high channel capacity and high data rate for 5G wireless and mobile communication MIMO technology is essential and to be applied. Different states and countries have assigned dissimilar bands from 3.3 GHz to 6 GHz sub-6 GHz range for the 5G mobile communication, and all these multiple licensed/unlicensed bands will be used for this new generation [12-15]. For that reason, a multi-port MIMO antenna that can uninterruptedly work from 3300 MHz to 6000 MHz is essential [16-18]. Nowadays, 8 × 8 MIMO or even 10 × 10 MIMO antenna array structure is presently essential as previous 2 × 2 MIMO array antennas for 4G (LTE) wireless mobile communications cannot fulfill the need of today high data rate [19-20].

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In the proposed design, a dual-band 8 elements MIMO antenna array is offered which covers 3.18-3.96 GHz & 4.95-5.52 GHz. The reconstruction of the decoupling design projected in this article does not simply increase the separations efficiently, but moreover creates a new booming theme in an alternative frequency band which covers 4.95 to 5.52 GHz to attain a dual-band working performance, consequently it can efficiently develop space use in cell phone devices [21-23]. The particulars of the presented MIMO compact antenna array are designated, and the outcomes of S-parameter, maximum gain, user effects, radiation and total efficiency of MIMO antenna array is also shown.

2 Design and Configuration

The design of this compact mobile MIMO 8-terminal antenna array is established via CST Microwave Studio electromagnetic simulation software [24]. The proposed design was developed on an FR4 substrate with relative permittivity ε_r=4.3 and dielectric loss tangent δ=0.019. The size of the main substrate is 150×75 mm^2 while the height of the substrate is 0.8mm. Every element of the antenna are located sideways the two wide sides of a 130×75 mm^2 ground plane, which is almost the identical measurement of today’s smart mobile phones. Eight antenna components are designed on two minor substrates which are placed perpendicular on the central system substrate [25-28].

The detail size of the small substrate is 130×6 mm^2 and the height of the substrate is 0.8 mm and as the main substrate, the 8-elements are designed on the FR4 substrate with relative permittivity ε_r = 4.3 and dielectric loss tangent δ=0.019 which is shown in Fig 1. There are two clarence ways that are situated at the upper and lower sides of the main substrate which is kept for 4G LTE and other antennas used in today’s smartphone mobile handsets. Fig. 2 display the transparent view and design details of the single element antennas.

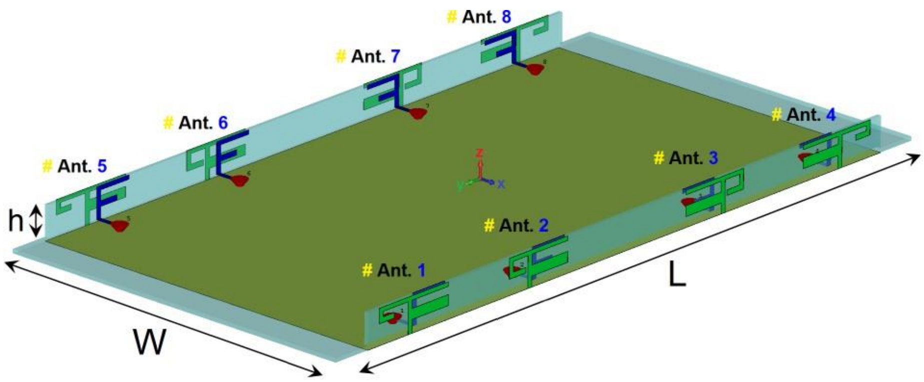
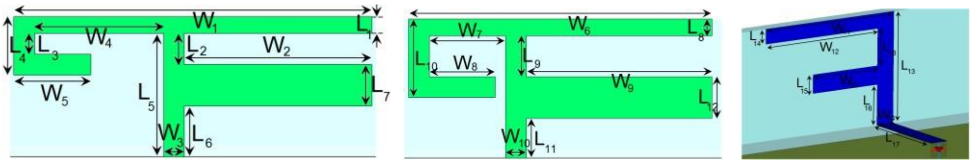


Fig. 1. Schematic structure of the designed MIMO smartphone antenna.



(a) (b) (c)

Fig. 2. The design details of (a) Ants.1, 4, 5, 8, (b) (a) Ants.2, 3, 6, 7, and (c) F-shaped feeding line.

Table 1. Final dimensions of the antenna parameters.

Parameter	W	L	h	W_1	L_1	W_2	L_2	W_3	L_3	W_4	L_4	W_5
Value (mm)	75	150	6		0.8	9	1.5	1.75	1	6.2	2.8	3.7
Parameter	L_5	W_6	L_6	W_7	L_7	W_8	L_8	W_9	L_9	W_{10}	L_{10}	W_{11}
Value (mm)	6	14.7	2.5	3.7	3	3.2	0.8	9	2	1	3.8	8
Parameter	L_{11}	W_{12}	L_{12}	W_{13}	L_{13}	W_{14}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	h_{sub}
Value (mm)	2	7	2	4	6	1	0.8	1	2.2	5	2	0.8

3 Results and Discussions

In this paper, the parameters and performance of the suggested 8-terminal MIMO antenna arrays are investigated using CST software. Every element is attached to a 50-ohm SMA connector to attain adequate S-parameters and the antenna was focused on to attain the detailed polarization return loss, radiation pattern, resonant frequency, and gain are the constraints which will be discussed in this paper.

The proposed 8-elements MIMO array operates at the dual-band from 3.18-3.96 GHz and 4.95 to 5.52 GHz covering the sub 6 GHz frequencies for the 5G mobile communications. Fig.3 shows the return loss (S_{nn}) of the projected antenna while Fig. 4 demonstrates the mutual coupling (S_{mn}) of the projected antenna. As presented, the simulated S_{22}, S_{33}, S_{66} and S_{77} are smaller than 15dB & -25dB at 3.6 & 5.2 GHz, respectively. However, for antenna elements including 1, 4, 5, and 8, the S_{nn} results are less than -25 dB at both resonance frequencies. This is principally due to the arrangement of the antenna elements [29-33]. As illustrated in Fig. 4, the antenna elements exhibit good mutual coupling results better than -12 dB and -20 dB at two operation bands.

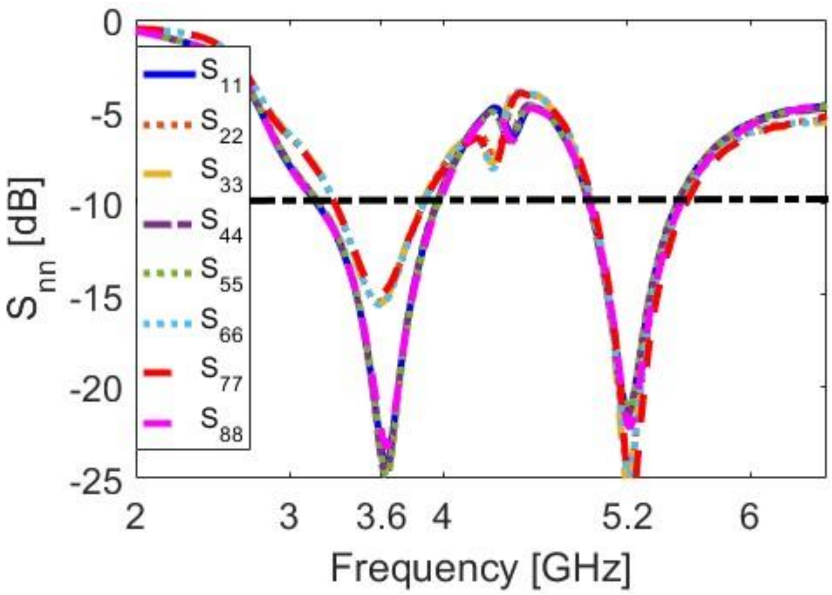


Fig. 3. Simulated return loss (S_{nn}) of the MIMO antenna array.

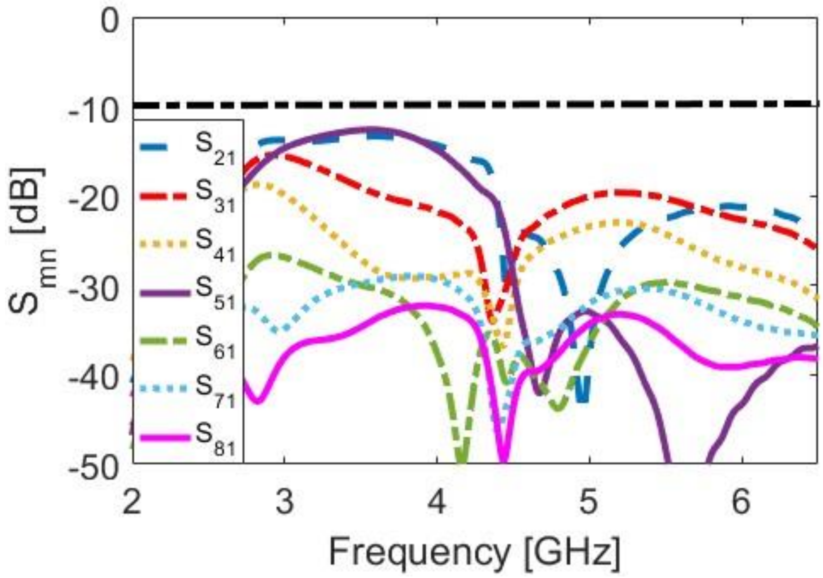


Fig. 4. Simulated mutual coupling results (S_{mn}) of the MIMO antenna array.

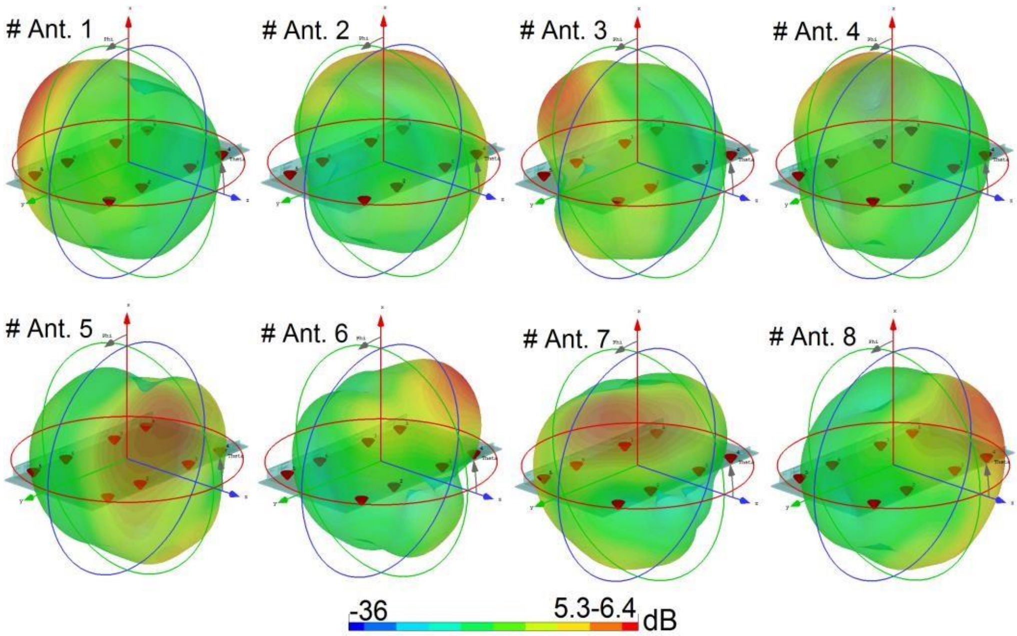


Fig. 5. 3D radiation shapes at 3.6 GHz.

The 3D radiation shapes for the eight elements of the core design at both operation frequencies including 3.6 GHz and 5.2 GHz are displayed in Figs. 5 and 6, respectively. It can be observed that the 8-element MIMO antenna can recommend adequate radiation coverage for each radiator [34-37]. As demonstrated, 3.6 GHz, the IEEE gain intensity of the design differs from 5.3 to more than 6.4 dB. However, at the second operation band (5.2 GHz), the elements exhibit constant gains of 4.9 dB.

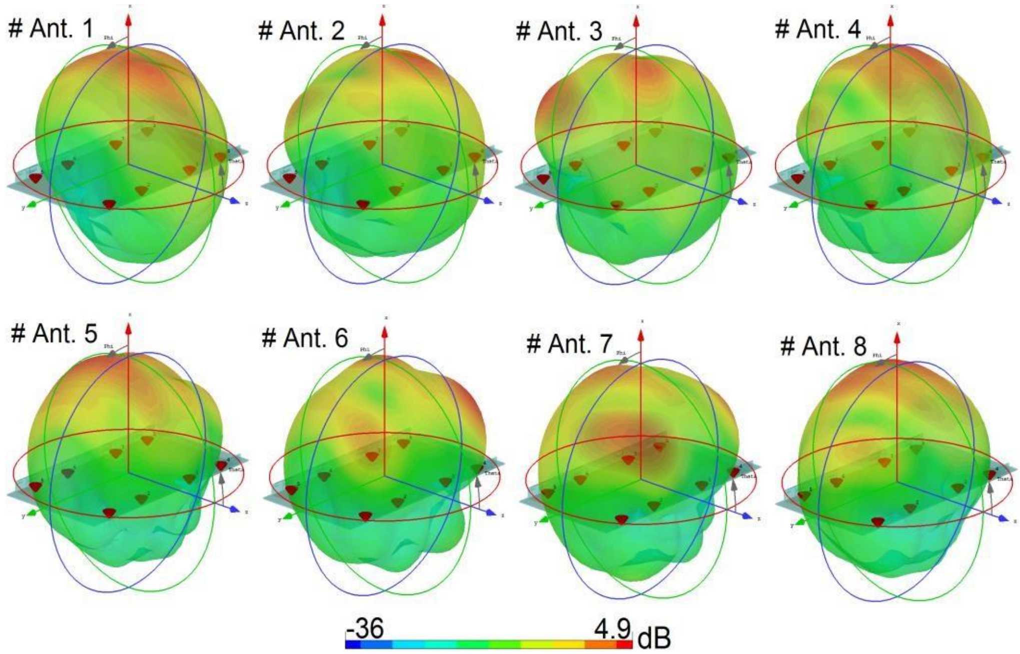


Fig. 6. 3D radiation shapes at 5.2 GHz.

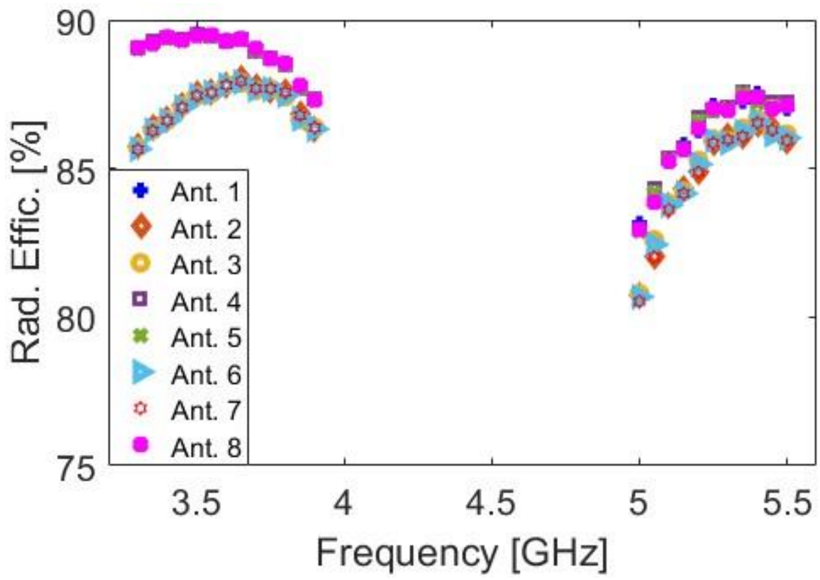


Fig. 7. Radiation efficiencies of the MIMO antenna over its operation band.

The efficiencies (radiation and total) of the antenna resonators are also presented in Figs. 7 and 8. It is evident that superior efficiencies with minor alterations are attained within the operation bands [38-40]. More than 85% and 80% radiation efficiencies were noticed for the elements of the projected MIMO design at the first and second operation bands. Moreover, as shown in Fig. 8, the antenna elements provide more than 60% and 70% total efficiencies.

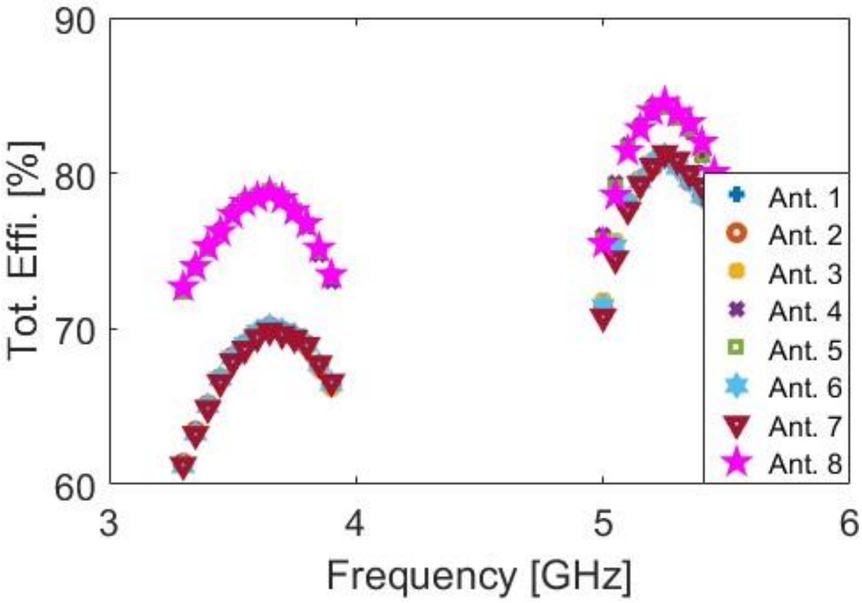


Fig. 8. Total efficiencies of the MIMO antenna over its operation band.

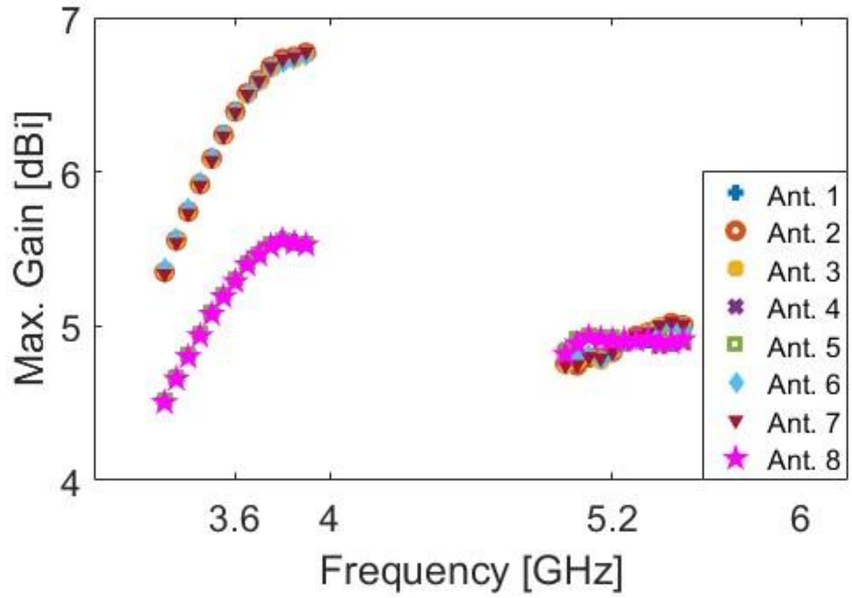


Fig. 9. Maximum gains of the MIMO antenna over its operation band.

The maximum gain results of the antenna elements are shown in Fig. 9. It is seen that all antenna elements exhibit more than 4.5 dBi up to 7 dBi maximum gains at different frequencies. As shown, unlike the first operation band with a centre frequency of 3.6 GHz, the maximum gains of the antenna at the second resonance are almost constant with the value of 5 dBi.

Conclusion

In this proposed article, a dual-band 8-port MIMO antenna array for 5G applications is presented. Utilizing a part of the copper edge as a radiation branch, the antenna array can work appropriately in a metal-frame smartphone. The consequences demonstrate that the working frequency band of the presented mobile antenna array can cover 3.18–3.96 GHz & 4.95-5.52 GHz. The antenna radiation and total efficiencies within the operating bandwidth are higher than 80% and 60% respectively. All results specify that the suggested MIMO antenna array is a worthy candidate for the future 5G massive MIMO mobile communication systems.

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