F-Shape Dual-Band MIMO Antenna System for Next-Generation Smartphone Applications

Atta Ullah¹, Naser Ojaroudi Parchin², Waqas Manan³, Yasir I. A. Al-Yasir⁴, Raed A. Abd-Alhameed⁵,⁶

¹,²,³,⁴,⁵,⁶A.Ullah5@Bradford.ac.uk, N.OjaroudiParchin@Bradford.ac.uk, R.A.A.Abd@Bradford.ac.uk

Faculty of Engineering and Informatics, University of Bradford, Bradford BD7 1DP, UK

Abstract. This work presents a 6-element dual-band multiple-input multiple-output (MIMO) antenna in an F-shape for smartphone mobile communication. It has six antenna elements covering dual-frequency bands that cover the sub-6 GHz spectrum at 3.42-3.77 GHz and the sub-6 GHz spectrum at 5.30-5.63 GHz. The fundamentals are served by F-shaped microstrip feeding positions while the ground is cut in L shape with every antenna element. The proposed scheme’s essential elements are examined. It is concerned with respectable S-parameters, adequate isolation, adequate radiation analysis, and efficiency. As proposed by the double-band frequency of 5G smartphones, Ant 3 has a maximum return loss of -35dB at 3.6 GHz and Ant 5 and Ant 6 have a maximum return loss of -38dB at 5.4 GHz.

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

1 Introduction

Following the release of the 5G New Radio (NR) in June 2018, fifth-generation (5G) telecommunications technology is once again anticipating exponential growth, necessitating the development of a 5G antenna design [1-2]. As mobile and communication technology becomes more widely adopted, the use of wireless technology and its applications has grown at a rapid pace. Artificial intelligence (AI), the internet of things (IoT), and mobile video streaming have all contributed to this significant advancement in wireless communication [3-4]. Fifth-generation mobile networks (or 5G) offer the latest solution for advancing wireless communication technology and achieving the mounting need for cell phone communications throughout the subsequent phase pending 6G arrives [5-8]. 5G is the definitive answer for wireless communication technology to achieve improved data rates and low latency [9-10]. Presently, the 5th generation of cellular phone communication of the band is recognized as dual regularity bands in 3.42 – 3.77 GHz and 5.30 – 5.63 GHz. The aggregate of 700 MHz bandwidth can be achieved[11-13]. Then in communication structures, multiple-input multiple-output (MIMO) practises can substantially enhance series operation and channel capability without increasing transmit power and increasing extra transmission bandwidth.
Nevertheless, as the reduction and probability of wireless gadgets turn out to be the typical mainstream, the accessible spaces for the antenna are further inadequate [14-16]. Hence, it is extremely crucial to project an efficient MIMO antenna. To adopt the frequently utilized wireless machines, publishing MIMO antenna is additional alternatives. Though, there is powerful mutual coupling when the space amongst MIMO antenna components is very close together. It is perverse to the aspiration for sharper isolation and lowers envelop correlation coefficients. Therefore, it is crucial to diminish the mutual coupling among the antenna components [17-18].

However, as the shrinking and compactness of developed wireless systems mainstream, the obtainable planetary for antennas is more restricted. Consequently, it is very compulsory to project a compressed MIMO antenna. To adapt to the usually used wireless systems, printing MIMO antennas is a basic choice [19]. However, there is solid mutual coupling when the detachment between MIMO antenna basics is very adjacent. It is conflicting to the aspiration for higher isolation and lower envelope correlation coefficients. It is crucial to decrease the mutual coupling among the antenna fundamentals [20].

5.30–5.63 GHz is accessible in the suggested architecture to facilitate Sub 6GHz 5G mobile communications. The modernization of the decoupling proposal proposed in this editorial not only efficiently increases separations, but also creates a new booming theme in an alternative frequency band, which covers 5.30 – 5.63 GHz to achieve dual-band working performance, allowing space use in mobile devices to be efficiently developed [21-23]. It describes the S-parameter, maximum gain, user effects, radiation, and efficiency results of the given MIMO compact antenna array.

2 Design and Configuration

With the aid of CST Microwave Studio electromagnetic simulation software an F-shaped 6 Fatal antenna array is designed for this compact mobile MIMO system [24]. FR4 was used with a dielectric loss δ=0.019 and ε_r=4.3 in the proposed project. The dimension of the central substrate is 140×70 mm^2 shown in Figs. 1 and 2 show the Front Side and BackSide respectively. Table 1 demonstrate the comprehensive scopes of the antenna parameters.
Fig 1. Front View of Schematic structure of the planned MIMO smartphone antenna.

Figure 2. Bottom View of Schematic arrangement of the planned handset.

Table 1. Concluding magnitudes of the antenna parameters.

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<th>L</th>
<th>h</th>
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<th>X_2</th>
<th>X_3</th>
<th>X_4</th>
<th>X_5</th>
<th>X_6</th>
<th>X_7</th>
<th>X_8</th>
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<td>18</td>
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<td>2</td>
<td>11.5</td>
<td>41.5</td>
<td>1</td>
<td>9.5</td>
<td>1</td>
<td>32</td>
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<tr>
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<td>X_8</td>
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3 Results and Discussions

Figure. The characteristics and performance of the suggested six-element MIMO antenna arrays are analysed using CST software in this proposed study [28]. The antenna was developed to achieve the specified divergence return loss, radiation pattern, resonance frequency, and gain, and it uses a 50-ohm SMA connector to produce the required S-parameters. All of these limitations are explained in this article.

In order to support Sub 6GHz of 5G mobile communications, a 6-fundamentals MIMO array offers dual-band radio frequencies from 3.42 to 3.77 GHz and from 5.30 to 5.63 GHz. Figure 3 shows the planned antenna's Snn. The proposed antenna's Snn (m not equal n) is shown in Figure 3. The computer-generated S55 and S66 are both less than -20dB at 3.6 GHz, whereas the simulated S11, S22, S33, and S55 are all less than -20dB at 5.45 GHz. However, at 3.6 GHz, the Snn results for antenna fundamentals 1, 2, 3, and 4 are less than -35 dB, whereas the Snn results for antenna fundamentals 5 and 6 are greater than -35 dB. The results are less than -40dB. The frequency is 5.45GHz. This is primarily owing to the antenna basics' positioning [29-33]. At dual working bands, the antenna fundamentals show good mutual coupling results better than -15 dB and -12 dB, as shown in Fig. 4.
Figures 5 and 6 show the 3-D radiation patterns for the six fundamental components of the primary design at both frequencies. This approved 6-part MIMO antenna is capable of providing sufficient radiation analysis for individual radiators [34-37]. Based on the illustrated results, this varies from 3.1-3.11 dB. However, at 5.45 GHz, the fundamentals exhibit a constant gain of 5.8 dB.
In Figures 7 and 8, we also show the antenna efficiencies. Inside the operating bands, extraordinary efficiencies with minor variations can be attained [38-44]. At the primary and additional working bands, radiation efficiencies exceed 95% and 90%, respectively, for the fundamentals of the proposed MIMO project. Furthermore, as shown in Figure 8, the antenna principles provide overall efficiencies of between 75 and 80 percent.

**Figure 6.** 3D radiation patterns at 5.45 GHz.

**Figure 7.** Variations of radiation efficiency versus frequency.
At various frequencies, all antenna essentials display superior gains of greater than 3 dBi up to 6.5 dBi. As can be seen, unlike the first operation band with a centre frequency of 3.6 GHz, the antenna’s maximum gains at the second resonance are nearly constant at 6 dBi.
4 Conclusion

An F-shape double-band 6-port 5G MIMO handset has been presented in this article. By exploiting some of the copper's radiation properties, the antenna array should suitably operate in a metal-framed smartphone. It is confirmed that 3.42 - 3.77 GHz and 5.30 - 5.63 GHz covered the required bandwidth. The antenna achieved 80% and 90% radiation and total efficiencies. Averged over the bandwidth.
References


Ojaroudparchin, N. et al.: 8×8 planar phased array antenna with high efficiency and insensitivity properties for 5G mobile base stations. EuCAP 2016, Switzerland (2016)


Al-Yasir, Y. et al.: New pattern reconfigurable circular disk antenna using two PIN diodes for WiMax/WiFi (IEEE 802.11a) applications. IEEE Proceeding of International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design (SMACD) 2019, Lausanne, Switzerland (2019)


Parchin, N. O. et al.: Multi-mode smartphone antenna array for 5G massive MIMO applications. EuCAP 2020, Copenhagen, Denmark (2020)


Ullah, A. et al.: Coplanar waveguide antenna with defected ground structure for 5G millimeter wave communications. IEEE MENACOMM'19, Bahrain (2019)