A Review on Dual Band MIMO Antenna for 5G Communications

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Abstract: ***The numerous Multiple-Input-Multiple-Output (MIMO) antennas are discussed in this survey work. The MIMO antenna is extremely important in today's wireless communications. In the decade gone by, a lot of research has been done in the subject of MIMO antennas. Various MIMO antennas and their parameters are discussed in this paper. This survey also looks at several MIMO antennas with different elements and how they affect MIMO antenna issues including mutual coupling characteristics. The near proximity of antennas causes excessive coupling, which reduces the effectiveness of the MIMO antenna system. The goal of this paper is to discuss recent research and development trends in 5G antenna design, as well as to highlight a few unique antenna design concepts with improved performance that are suitable for MIMO applications.***

Keywords: MIMO, 5G, Decoupling techniques, Dual-Band and ECC

1. Introduction

The continuously increasing demand for larger data rates is one of the primary motivations prompting the creation of MIMO antenna. In order to boost data transfer speeds in the future, the upcoming fifth-generation (5G) communication has got a lot of press. Understanding the propagation channels is critical for correctly building and testing 5G communications networks [1], which necessitates a huge number of channel measurements. MIMO technology has recently got a lot of interest in the field of wireless communication systems development. In order to accommodate a faster data rates, 5G mobile networks are already extending their spectrum. The World Radio Communication Conference (WRC) assigned frequency bands below 6 GHz for 5G candidates in 2015, with frequency ranges of 470–694, 2300–2700, 3300–3800, and 4500–4990 MHz proposed. Since it is widely recognized in most nations, sub 6 GHz band for 5G has got a lot of attention [2-3].

However, reducing mutual coupling between antenna parts in a small space while retaining dual-band operation and good gain is a difficult task. A Dual-band antennas has been designed using a number of approaches, including metallic resonators, slots, and stub elements. To improve the properties of isolation and bandwidth, numerous strategies have been described. The Slot loading, defective ground structure, neutralization lines, stub elements and orthogonal elements are some of the decoupling strategies that have been presented. A dual band MIMO antenna that achieves isolation of more than 15 dB using slot loading is presented [4]. A Compact monopole with T shape structure for dual band application has been reported [5]. The orthogonal Antenna element used defected ground structure to improve the mutual coupling reported [6]. The F bend shaped monopole MIMO antenna with T shape stub element is introduced to better isolation [7]. The neutralization lines structure has been used to improve isolation of MIMO antenna [8]. The T shaped and metallic strip MIMO structure consist of partial gnd and orthogonal element for 5G Smartphone applications is reported [9].

The focus of this research is on the design of MIMO antenna and strategy for improving the antenna's performance. To reduce size, mutual coupling, and improve efficiency, several forms and approaches have been adopted.

2. Literature Survey

The mutual coupling of antennas affects the performance of the metallic printed structure due to the use of numerous antenna. The isolation is increased using slot loaded in ground plane. The structure consists microstrip slot loaded antenna and the dual band is achieved by using symmetrical T slots [4]. Figure 1 shows the structure of a MIMO antenna with slot.

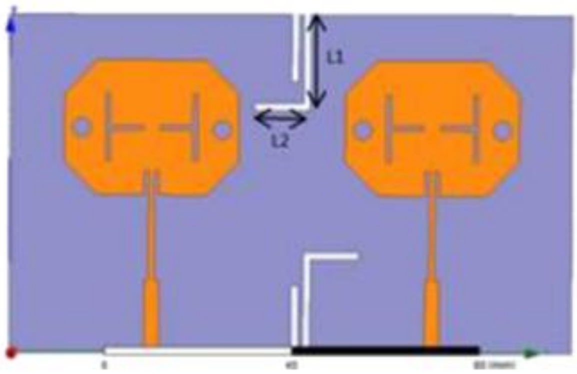

Figure 1: Structure of MIMO Antenna with slot loaded

Researchers provide a 2-element dual slot MIMO antenna at 2.4 GHz and 3.4 GHz.

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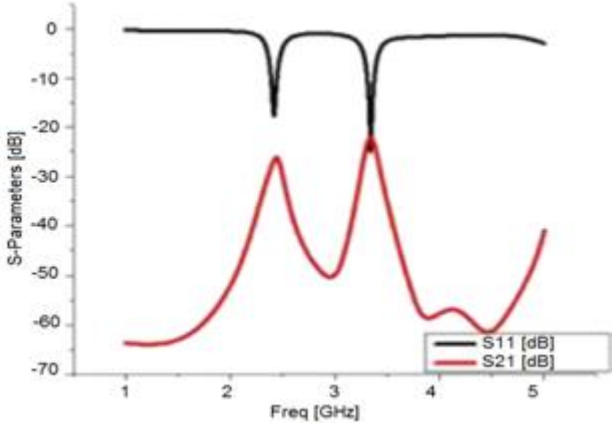

Figure 2: Simulated S-parameters

In Fig.2, the proposed antenna covered dual band operations with a better than 20dB isolation for the both bands was achieved.

Two symmetrical monopoles configurations are provided for WLAN applications [5]. The antenna covers two bands: 2.3-3.0 GHz and 5.1-5.5 GHz. The monopole antenna connected T shaped junction metallic strip create which is used to obtain dual frequency band of 2.7 GHz and 5.3 GHz. The Partial ground consists of multiple slots to improved isolation of MIMO antenna. Figure 3 shows the antenna geometry.

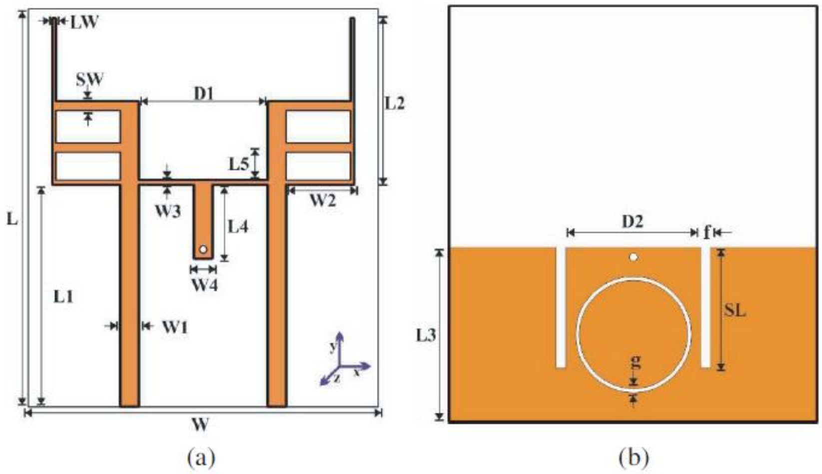

Figure 3: Dual band MIMO Antenna. (a) Top View. (b) Bottom View

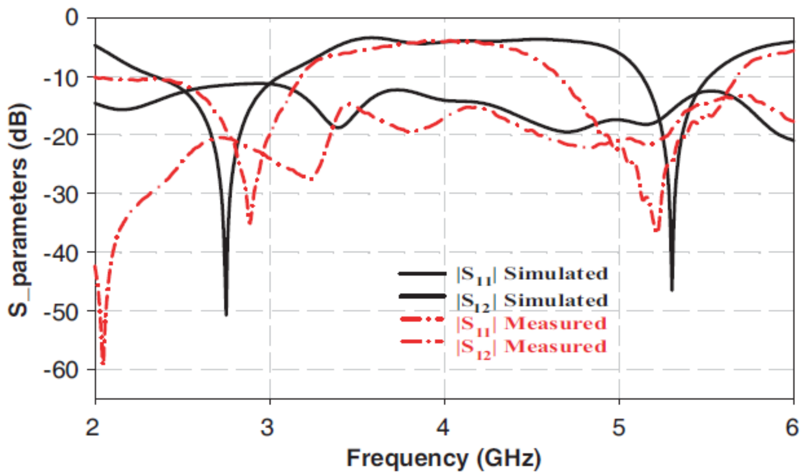

Figure 4: Simulated Vs Measured S-Parameter's MIMO Antenna

The measured findings varied slightly from the simulated results. The inconsistencies could be caused by connector losses utilised in testing aren't taken into account in simulation.

For the LTE and WLAN applications, ref [6] proposes a compact 2 element MIMO structure. The dual band is obtained by adding three short stubs in radiating element. The antenna provides good mutual coupling for placing antenna perpendicular to each other.

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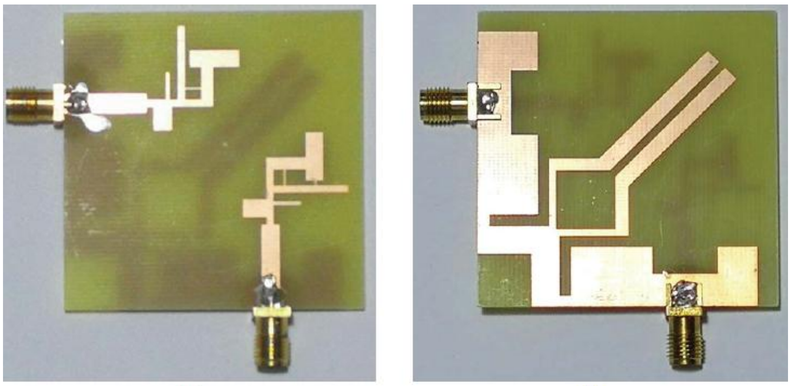


(a) (b)

Figure 5: Geometry of MIMO antenna (b) Top view and (c) bottom view

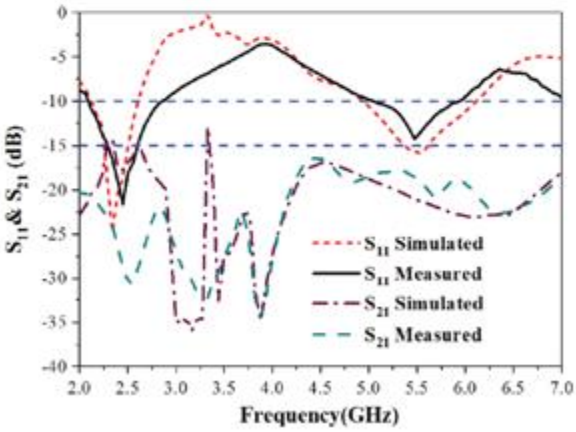


Figure 6: S-parameter of MIMO simulated Vs measured.

Fig. 6 further revealed that at 2.4 GHz and 5.5 GHz, S21 is below 17 dB, implying a strong separation between the antenna ports. Except for certain variation in results may be due to dielectric and conductor losses, production defects, soldering, and impacts of the SMA connector.

An F-shape Dual band MIMO for WLAN and WiMAX applications reported in ref [7]. Antenna consists of L shape, F shape and bent F shape structures. Slot in the ground plane and T-shaped ground stub took care of mutual coupling reduction process. The antenna can operate at 2.3-2.6 GHz and 5.1-5.3 GHz frequency band, which is suitable for wireless communications. The small and F-shape metallic strip has been used to reduce size of antenna. With the use of DGS technique, more than 15 dB isolation was achieved.

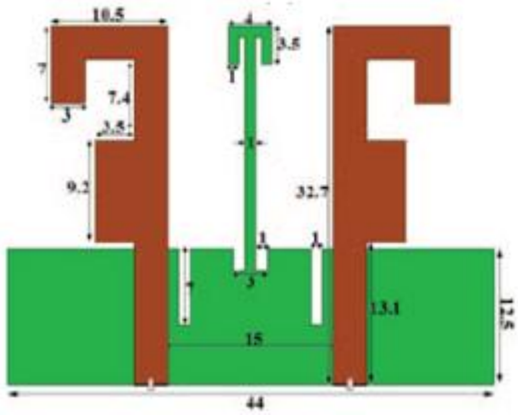
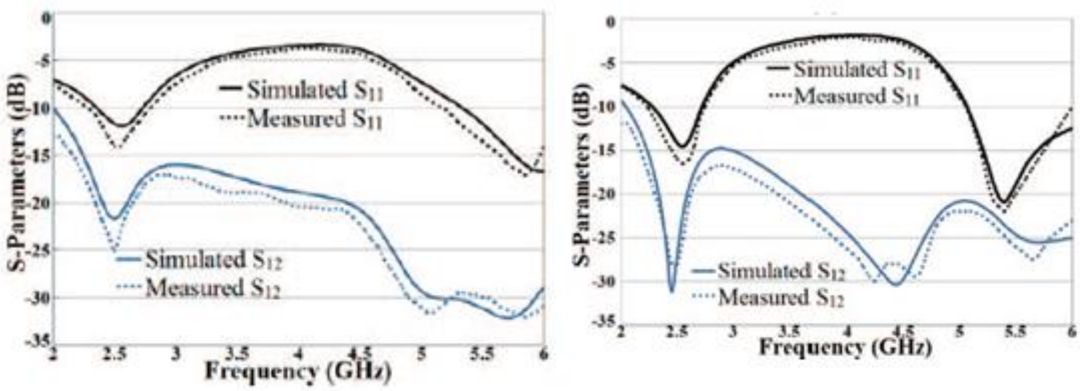


Figure 7: Geometry of the F bend MIMO antenna



(a) (b)

Figure 8: Simulated (a) reflection coefficients (b) isolations

Fig. 8(b) depicts the dual band MIMO antenna offer isolation below 15 dB for the both frequency band.

In reference [8], 2 element slot MIMO antenna is presented for 5G mobile communication. The antenna operated bandwidth from 3.4–3.6 GHz and 5.1–5.8 GHz. The Dual band characterises obtain by using slotted structure. To improve isolation, the decoupling neutralization line has been used in ground plane. The lower band isolation is below 12 dB, and the upper band isolation is below 15 dB.

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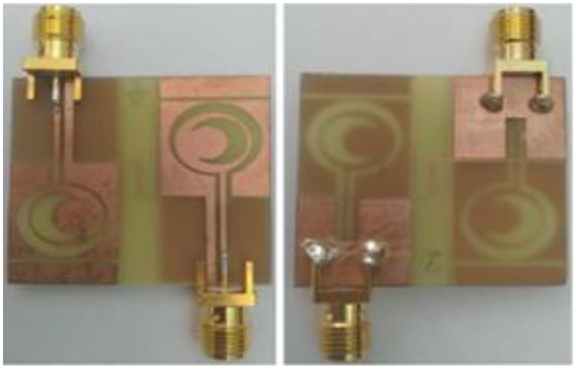


(a) (b)
Figure 9: MIMO structure (a) Antenna Top View (b) Bottom View

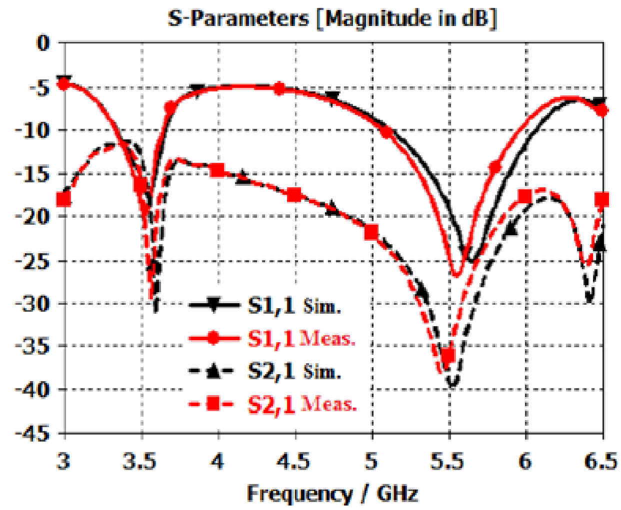
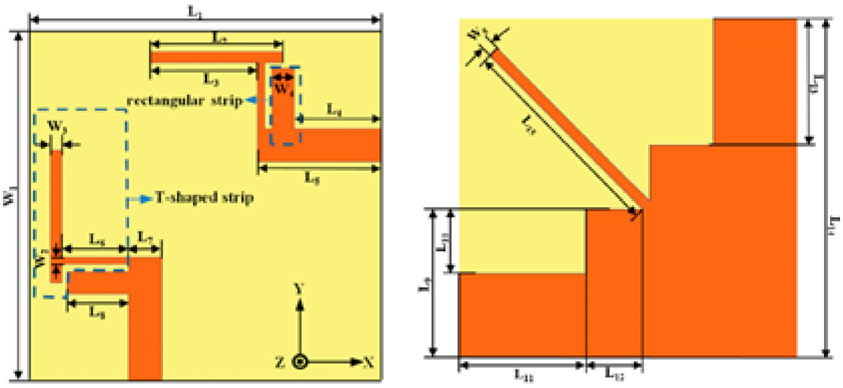
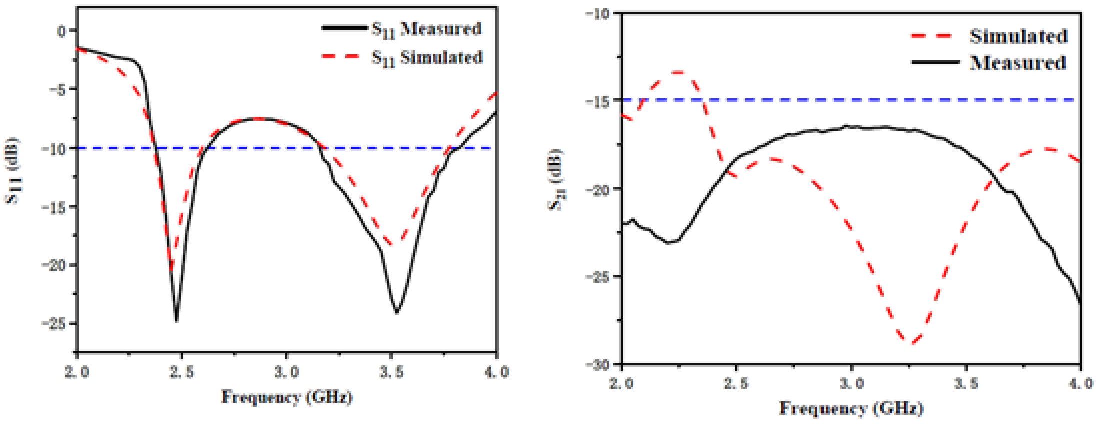


Figure 10: Simulated and measured S-Parameters of MIMO antenna

In ref [9], a dual-band MIMO antenna working in the band of (2.5-2.6 GHz) is reported for (5G) n7 and (4G) Long Term Evolution (LTE) band 42 (3.4–3.6 GHz) communication. The antenna consists of two identical monopole antenna which placed in orthogonal position. As a result, the coupling between the two antenna elements can be decreased, resulting in improved isolation characteristics.



(a) (b)
Figure 11: MIMO Antenna Geometry



(a) (b)
Figure 12: Measured Vs Simulated (a) S11 (b) Isolation

The simulated and measured reflection coefficients are shown in Fig. 12. There was a little discrepancy between the measurement and simulation results, which could be attributed to a variety of factors. We can tell from the measurements that the bandwidth is quite large**.** The two frequency bands that have been realized can cover 5G (3.5 GHz) and 4G LTE (2.4GHz).

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Table 1: Comparison of existing Dual Band MIMO antenna for 5G Communication

Ref.	Size (mm^2)	Freq. (GHz)	Isolation (S21) (dB)	Gain [dB]	ECC	Isolation Techniques Used
Ref [4]	60 x 70	2.4 /3.4	>16	1.8	0.02	Slot loading
Ref [5]	38 x 43	2.7 /5.3	>12	2.0	0.01	Defected Ground Structure
Ref [6]	50 x 50	2.4 / 5.5	>17	4.5	0.01	Defected Ground Structure
Ref [7]	33 x 44	2.5 /5.5	>15	2.0	0.03	T-shape stub element
Ref [8]	31 x 31	3.5 /5.5	>12	3.0	0.02	neutralization lines
Ref [9]	32 x 32	2.4 / 3.4	>15	5.0	0.02	Orthogonal element

Existing Dual band MIMO antennas were compared based on various antenna parameters are represented in Table 1. Isolation are improved by different methods in the paper which are shown above.

3. MIMO Antenna Performance Analysis

The Envelope Correlation Coefficient (ECC), Polarization Ratio, Total Active Reflection Coefficient (TARC) and Diversity Gain (DG) are used to calculate the MIMO antenna performance. Every parameter, such as TARC and ECC, has an acceptable limit that should be as small as feasible. ECC values should be less than 0.5 in general. The TARC value should be less than -10 dB. The allowable diversity gain limit is around 10 dB.

a) Envelope Correlation Coefficient (ECC)

ECC is a prominence factor for evaluating orthogonal polarization diversity of circularly polarized MIMO antenna. ECC parameter is calculated by using the following equation:

$$ECC = \frac{|S_{11}^* S_{12} + S_{21}^* S_{22}|^2}{(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)}$$

b) B. Total Active Reflection Coefficient (CCL)

TARC is also the prominent factor which is calculated using S-parameters of the MIMO antenna. The TARC is expressed by the formula given below.

$$TARC = \sqrt{\frac{(S_{11} + S_{12})^2 + (S_{21} + S_{22})^2}{2}}$$

c) Diversity Gain (DG)

DG parameter is used to find the signal to interference ratio of MIMO antenna. DG is obtained by below equations.

$$DG = 10\sqrt{1 - ECC^2}$$

4. Conclusion

Many Dual band MIMO antennas for 5G applications are discussed in this survey paper. The important results of this study are tabulated in the comparative analysis section. According to this survey research, the main issue with reciprocal pairing is the need for a separate MIMO antenna. The majority of the design antennas have a low isolation problem. This paper provides an overview of these antennas and isolation strategies. For both existing and future wireless terminals, Dual-band printed MIMO antenna systems are particularly valuable. Dual-band with isolation enhancement structures are necessary for densely packed printed MIMO antenna systems. As we swiftly progress towards 5G NR mobile terminal applications, it is determined that MIMO antenna has provided a large amount of possibilities for research and development in the antenna architectural area.

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