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Analysis of LTE based an Antenna Design for 5G Communications

Angotu Saida[1], R. K. Yadav[2], V.K. Sharma[3]
[1]Research Scholar, Department of ECE, Bhagwant University & Department of ECE, KG Reddy College of Engineering and Technology, Hyderabad, India
angotusaida2@gmail.com
[2]Research Supervisor, Bhagwant University, Rajasthan-India & Goel Institute of Technology Ghaziabad, U. P, India
ravipusad@gmail.com
[3]Research Supervisor, Bhagwant University, Dept. of EEE, Bhagwant University, Ajmer, India
viren_krec@yahoo.com

Abstract— As the world progresses towards the next generation of communications networks, new technological solutions, architectures and standards are urgently required. This evolution of communications networks will facilitate numerous convincing business and consumer applications and speed up large investments in network infrastructure, appliances and devices. Wireless technologies of the last generation, 5G networks, promise an era of all-round, secure and powerful radio network. The use of 5G technology extends beyond traditional telecoms, and includes extremely low latencies, high energy efficiency or comprehensive Gbps. This paper also accurately includes 5G requirements and antenna categorization accompanied by a comparative study of various antenna designs. The various researchers have previously suggested several 5G antenna designs, but an exhaustive examination using their performance improvement system of the various types of 5G antenna has not yet been completed. We thus tried to examine the various types of 5G antenna design, their mechanisms for improving performance, comparisons and possible worldwide breakthroughs.

Keywords: LTE, MIMO, SISO, UWB, 5G Antenna.

I. INTRODUCTION

The evolution of cellular wireless networks:

The first 1G system has been launched since 1981 and a new cellular generation has appeared around every 10 years [1]. The telecommunications industry, through four or five decades of technological revolution and development - 1G, 2G, 3G and 4G network innovations - has changed society in the last 30 years (Fig. 1). 1G has given us a cell phone mass-market. 2G introduced world-wide interoperability and confident mobile phone service and allowed SMS text messaging. 3G provided us with the opportunity to download data from the Internet high-speed data transfer.[2]4G has improved the data capacity and speed significantly, and made available to masses online networks and high-speed mobile Internet services. 5G technology becomes the most efficient wireless cellular networks with outstanding storage capacity, unlimited call volumes and infinite data transmission [3].

Radio frequencies (also known as spectrum) are used for transmission of information through the air by wireless communication systems. 5G functions in equal measure, but uses higher, less confused radio frequencies. This helps it to have much faster details. These top bands are referred to as 'millimeter waves' (mm waves) [4]. They were unused before, but they were opened to regulators for licensing. The public had not touched them largely because the equipment for their use was largely unavailable and costly. Though higher bands carry information faster, transmitting information on long distances can be difficult. Physical objects like trees and buildings are easily blocked. 5G uses multiple input and antenna outputs to increase signals and power across the wireless network in order to overcome this problem [5]. Smaller transmitters are used as well. Instead of stand-alone masts, placed on buildings and street furniture, Current estimates state that up to 1,000 devices more per meter than 4G will be supported by 5G.

Furthermore, a physical network can be "sliced" into many virtual networks. This ensures that operators can supply the best network section according to how it is used and control their networks better [6]. For example, this means that an operator can use various slice capacity, depending on its usage. A single user streaming a video would thus use an alternative slice to a corporation, while simple devices could be removed, such as controlling standalone vehicles, from more complex and demanding applications [7-8]. Companies often intend to lease their own independent and isolated network slices to isolate them from competitive internet traffic.

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II. OUTLINE OF 5G ANTENNAS: TYPES AND THEIR IMPROVED TECHNIQUES

A. DIFFENRENT TYPES

In the last few years, several 5G antenna designs with various performance improvement technologies have been proposed. These models were categorized by input and antenna types in this section.

1) CLASSIFICATION BASED ON I/O PORTS

In given Figure 2, we found that the best way to identify the antenna is to enter output ports. They can divide the antenna in:

• **SISO:** Some scientists used Single Input Single Output (SISO) antenna for 5G applications. The SISO aerial can be easily developed and implemented. In addition, 5G networking applications can be conveniently incorporated into it. In order to achieve great gain [10]. Signal losses and service quality are greater at over 6 GHz frequency bands. There are higher signals. A single element antenna must therefore be replaced with a multi-element antenna for a consistent and efficient performance. A multi-element antenna's main purpose is to increase the acquisition and design complexity of an antenna for larger dimensions.

• **Multiple Input Multiple Outputs (MIMO):** Wireless contact is susceptible to interruption, decay and loss of radiation. At higher frequencies, it also becomes serious. To overcome such difficulties, it is important to use multiple input multiple antennas (MIMO), which increase the range of transmission without signal power. In addition to low latency, optimal efficiency and great reliability, 5G MIMO architecture can be used. MIMO can use multiple antennas to smartly start more signals and greatly enhance channel power.

The means by which the number of antennas in MIMO is reduced by a multi band antenna that provides coverage for various wireless applications. In addition, MIMO antennas can be categorized as broadband and multiband antennas according to their frequency band. Furthermore, broadband and multi-band aerials can be implemented as multi-element components without metals and multi element aerials.

B. CLASSIFICATION ON TYPES OF ANTENNA

As given in Figure 3, another significant classification method may be based on antenna forms. The various types of antennas are as follows according to the literature appropriate for 5G applications:

• **Monopole Aerial:** It has μ/4 long line of microstrip, β being the wavelength of the antenna resonance frequency. As can be seen in literature, several changes were suggested that would transform a basic structure, as applications and specifications, into new forms such as conic, spiral and other.

• **Dipole Antenna:** There are two straight lines of λ /4, each of which is feeding between the two lines of microstrip. Therefore λ/2 is the complete length of the dipole antenna.

• **Magneto-Electric (ME) Dipole Antenna:** There are two straight lines of т/4, each of which is feeding between the two lines of microstrip. Therefore λ /2 is the complete length of the dipole antenna.

• Loop Antenna: It is a round, rectangle, square or some other ring type. It is less than the wave-length of this loop antenna.

• **Vivaldi Aerial:** It has two conductors and mirror copies on either sides of the substratum. The top driver serves as a radiator while the bottom driver functions as a foundation.

• **Fractal Aerial:** It is repeated several times by the same structure. It is constructed with a mathematical iterative law. The fractal aerial can be implemented with different shapes, including triangle, circle, rectangle, blade, and star.

• **Inverted F Aerial:** The microstrip is made of a single curvature and is supplied to the right portion of the microstrip. The feed point is near the flexible component, so that the antenna type F is generally visible.

• **Planar Inverted F Aerial:** It comprises the parchment Aerial and the floor plane connected to a shortening tube. It takes less space since it resonates at the fourth wavelength.

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III. PROPOSED ANTENNA DESIGN

Using the HFSS, the proposal was designed and simulated. The modeling was based on a substratum of loss tangent $\delta = 0.0037$ and $\varepsilon r = 3.6$, Rogers RO4350B as given in Figure 1. Figure1. The geometric substratum is 110 x 75 × 0.76 mm^3. It has the MIMO element is on the top side of the dielectric supporting the Long Term Evolution frequency bands, while the antennas are framed on the extended edge of the board with a wave band of five mm.

For each MIMO mm-wave antenna there is a two element linear array with a feed network. In addition, the DGS structure on the ground is applied to achieve better radiation efficiency as shown in Figure 1b. For the MIMO aerial system that is shown, Table 1 provides optimized parameter values. The design progression consists of defining first the single-

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element LTE and 5G antennas, Then a MIMO setup and then a two-structure combination.

Table1. Optimized Dimension of Proposed Design

Name	Value (mm)	Name	Value (mm)	Name	Value (mm)
4G/LTE Antenna parameters					
L_s	25	W_s	21	L_p	11.8
L_f	8.76	W_f	2.2	W_p	19
L_{p1}	3.3	W_{p1}	3.4	L_{p2}	2.5
W_{p2}	3.4	R_1	6		
5G Single-element and Antenna Array Parameters					
L_s	6	W_s	6.2	L_p	4.2
L_f	1.7	W_f	1.5	W_p	3.6
S_l	1.35	S_w	2	L_{f2}	1.28
L_{f1}	4.4	W_{f1}	1.6	W_{f2}	0.4
L_{g1}	12.5	W_{g1}	1.35	R_2	1.3
4G/LTE and 5G Integrated Design					
L	110	W	75		

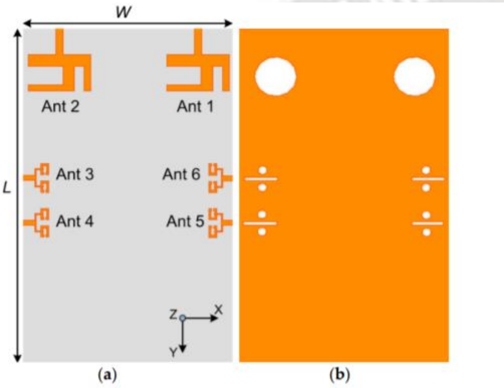

Figure1. The Long Term Evolution and 5G multiple outputs input aerial system geometry is integrated: Aerial System: (a) Top Sight; (b) Back Sight. [5]

Table2. Optimized Values of Proposed Design

Name	Value (mm)	Name	Value (mm)	Name	Value (mm)
4G/LTE Antenna parameters					
L_s	25	W_s	21	L_p	11.8
L_f	8.76	W_f	2.2	W_p	19
L_{p1}	3.3	W_{p1}	3.4	L_{p2}	2.5
W_{p2}	3.4	R_1	6		
5G Single-element and Antenna Array Parameters					
L_s	6	W_s	6.2	L_p	4.2
L_f	1.7	W_f	1.5	W_p	3.6
S_l	1.35	S_w	2	L_{f2}	1.28
L_{f1}	4.4	W_{f1}	1.6	W_{f2}	0.4
L_{g1}	12.5	W_{g1}	1.35	R_2	1.3
4G/LTE and 5G Integrated Design					
L	110	W	75		

3.1 LTE Antenna Configuration

The Long Term Evolution frequency bands shown in figure 2, the systemic configuration of the inverted Y antenna is suggested with 50 meters matched microstrip feedline. The Y-shaped aerial is modeled on the substratum of Ls-i.e., Ws For the 50Ω to impedance fitting the characteristic equations of the transmission line, the Wf width of the feedline is amended. Also in the following mathematical equations is the primary structure of the rectangular aerial radiating in the required frequency.

$$W_p = \frac{c}{2 f_c \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

$$L_p = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}} - 2\Delta L$$

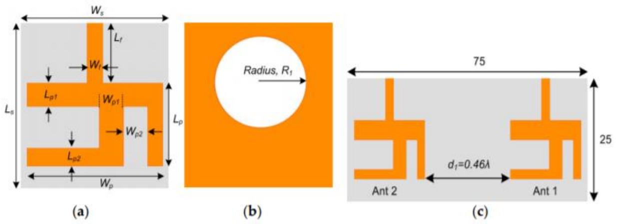

Figure2. (a) one element, front view; (b) one element, (c) reverse view; (a) reverse antenna view. Geometry. [3]

The L TE single-patch antenna and the MIMO array, as shown in Figure 3a and b and respectively, are studied in the reflection coefficient and transmission coefficient curves. The LTE single-element antenna from the S11 curve is apparently fitted with the LTE band (47) and section 46 of the LTE band, with working bands of 630 MHz from 5.62 up to 6.25 GHz. Furthermore, the S11 and S22 plots show that the components Ant1 and Ant2 resonates with GHz and 5.72-5,97 GHz within the frequency ranges.

Current day more research is progressing on miniaturization of antennas and in UWB band [9-15] as UWB designs has its own advantages and many IOT applications today are using this bad.

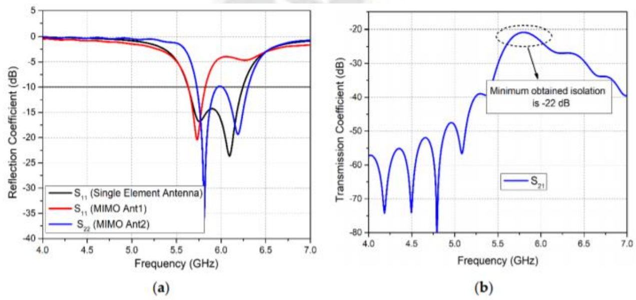

Figure3. Curves for LTE antenna with simulated S-parameter: (a) Reflective Curves; (b) Transmission Curve Coefficient.[1]

IV. EXPERIMENTAL RESULTS

The proposed MIMO integrated antenna prototype was made with the photolithography method on a Rogers RO4350B substrate in order to experimentally demonstrate it [16], [17]. The prototype manufactured, the S-parameter measurement setup and the setup for the measurements in the far field are

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shown in Figure 4a–c. The following analyzes the experimental effects of the antenna efficiency sensors.

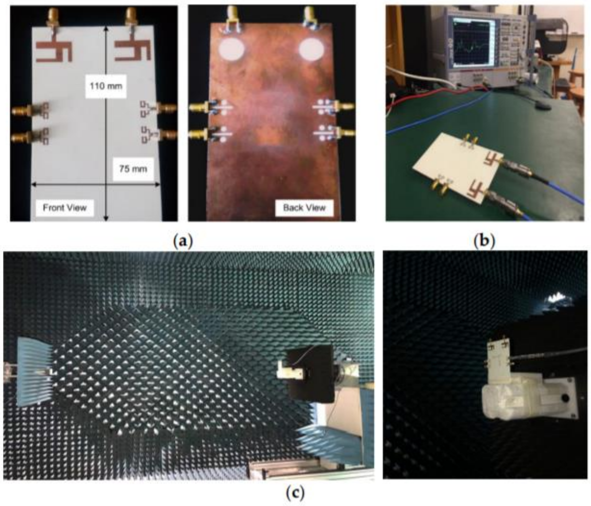

Figure4. (a) Manufactured front and back vision prototypes; (b) Vector Network Analyzer (VNA) S-parameter measurement; (c) Farfeld measurement setup

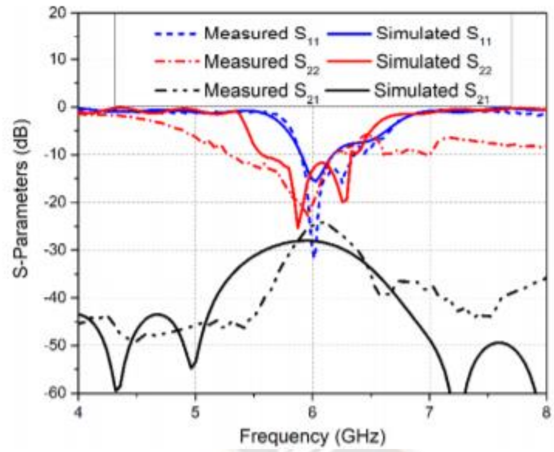

Figure5. Curves S-parameter simulated and tested for LTE MIMO antennas.

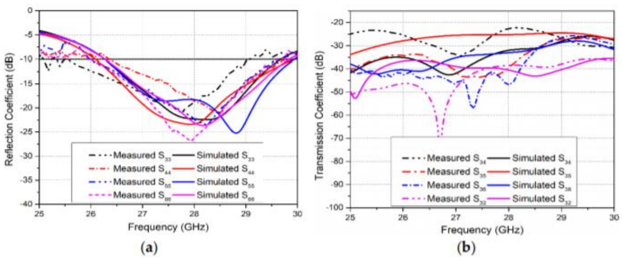

Figure6. S-parameter parcels simulated and measured for designed antenna: (a) S11; (b) S12

MIMO Performance Analysis

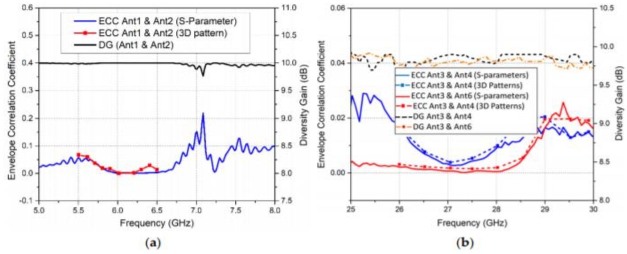

Figure7. (a), MIMO antennae, ECC and diversity gain. (b), 5G MIMO antennae;

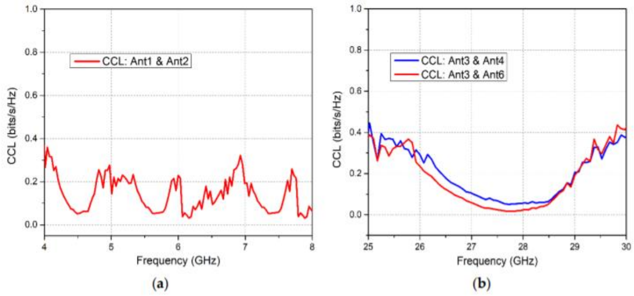

Figure8. (a) Long Term Evolution MIMO aerial (b) 5G MIMO aerial Channel Capacity Loss

Conclusions

A 5G Multiple Inputs Multiple Output and Long Term Evolution aerial are presented for wireless networking applications. The work presented here has two components of the Long Term Evolution MIMO aerial system, while there are four MIMO elements for the 5G module. With a maximum measured bandwidth of -10 dB of 830 MHz, LTE Antenna Modules protected LTE 46 and 47 channels. The bandwidth measured from the 5G mm-wave configuration of the MIMO aerial was also 3.5 GHz and included a 28 GHz band. In addition, the design showed a microwave frequency and a mm-wave frequency band isolation of more than 25 and 22 dB respectively. In addition, maximum gains respectively of 5.13 dB and 9.53 dB were obtained with the proposed MIMO and the proposed Long Term Evolution aerials. The DG, TARC, CCL, ECC and MEG measured values have confirmed the success of the MIMO antennas proposed. In addition, in compliance with human safety requirements, the antenna system proposed achieved poor PD and SARs.

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