MINIATURIZED HIGH GAIN INFINITY STRUTURE BASED MIMO ANTENNA FOR 5G SMART PHONE APPLICATIONS

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Abstract

In this work, a novel single layer hexagonal Multiple Input–Multiple Output (MIMO) antenna for Fifth-Generation (5G) 23 GHz frequency band applications is proposed and investigated. The proposed MIMO antenna operates in the Ka-band, which is the most desirable frequency band for 5G mm-wave communication. The dielectric material is a Rogers-5880 with a relative permittivity, thickness and loss tangent of 2.2, 0.56 mm and 0.0009, respectively, in the proposed antenna design. The proposed MIMO configuration antenna element consists of triplet circular shaped rings surrounded by an infinity-shaped shell. The simulated gain achieved by the proposed design is 6.1 dBi, while the measured gain is 5.5 dBi. Furthermore, the measured and simulated antenna efficiency is 90% and 92%, respectively. One of the MIMO performance metrics—i.e., the Envelope Correlation Coefficient (ECC)—is also analyzed and found to be less than 0.16 for the entire operating bandwidth. The proposed MIMO design operates efficiently with a low ECC, better efficiency and a satisfactory gain, showing that the proposed design is a potential

Introduction

5G networks are cellular networks, in which the service area is divided into small geographical areas called cells. All 5G wireless devices in a cell communicate by radio waves with a cellular base station via fixed antennas, over frequency channels assigned by the base station. The base stations, termed gNodeBs, are connected to switching centers in the telephone network and routers for Internet access by high-bandwidth optical fiber or wireless backhaul connections.

As in other cellular networks, a mobile device moving from one cell to another is automatically handed off seamlessly to the current cell. 5G can support up to a million devices per square kilometer, while 4G supports only one-tenth of that capacity. MIMO systems use multiple antennas at the transmitter and receiver ends of a wireless communication system. Multiple antennas use the spatial dimension for multiplexing in addition to the time and frequency ones, without changing the bandwidth requirements of the system. Massive MIMO (multiple-input and multiple-output) antennas increases sector throughput and capacity density using large numbers of antennas. This includes Single User MIMO and Multi-user MIMO (MU-MIMO). Each antenna is individually-controlled and may embed radio transceiver components. Li, Y et al proposed an eight-element multiple-input multiple-output (MIMO) antenna array for 5G/WLAN micro wireless access points. The proposed MIMO antenna is formed by integrating eight identical antenna elements. For each array element, four operation bands, namely, LTE bands 42/43 (3400–3800 MHz), 4.9-GHz band (4800–5000 MHz) and 5.2-GHz WLAN (5150–5350 MHz) are fully covered for 8 × 8 MIMO use. Zou, H et al presented a dual-band 6 × 6 antenna array operating in the LTE band7 downlink

(2620–2690 MHz) and LTE band46 (5150– 5925 MHz) for 4.5G/5G communication multi-input multi-output (MIMO) operation in the smartphone. The proposed dual-band antenna array elements are symmetrically placed along the long edges of the smartphone, and the antenna element is composed of three parts: a L-shaped feeding monopole, a grounded monopole and a cuboid-shaped carrier. Li, Y., Zou, H., Wang, M., Peng, M., & Yang, G. (2018). A Quad-Band Eight-Antenna Array for 5G/WLAN MIMO in Micro Wireless Access Points. 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting.Hu, H.-N et al proposed a dual linearly-polarized antenna subarray that operates at 28 GHz and 38 GHz for fifth generation (5G) base stations. In contrast to earlier millimeter-wave base-station antennas that implement individual single-band antennas, simultaneous realization of dual-band operation can save space and cost. In addition, the proposed subarray depicts dual polarizations, improving signal reliability through polarization diversity. Furthermore, the proposed subarray is scalable and expandable in size and aperture. The proposed antenna subarray consists of 2 × 2 dual off-center-fed dipoles.

Wang, Y.-Y et al proposed a integrated design of 4G antennas and 5G antennas applied to glasses .The most important highlight of this design is that it makes full use of the limited three-dimensional space structure provided by glasses and achieves the perfect combination of the antenna and glasses in the physical structured Costa, I. F et al reports an innovative structure and preliminary results of a four-elements antenna array with beam steering for 5G access cellular networks, operating in the underutilized millimeter wave (mm-wave) frequency spectrum. Alja'afreh**, S..S** et al proposed a self-isolated 10-element antenna array operating in the long-term evolution 42 (LTE42) frequency band for 5G massive MIMO smartphone applications. The proposed antenna elements are placed in a 2D array configuration; they are placed symmetrically along the two long edges of the mobile chassis. The proposed antenna structure is a shorted loop antenna resonating at half-wavelength mode, which is rarely deployed by researchers due to its large size compared to other quarter wavelength antenna structures.

Chattha, H. T. et al presented a compact, low-profile four-port, two-element antenna for 5G Internet of Things (IoT) and handheld applications having a height h = 3.0 mm. The antenna structure contains two planar Inverted-F antenna (PIFA) elements having same shapes. Each antenna element has two feeding plates placed at right angle to each other to make them cross-polarized for the exploitation of polarization diversity, whereas spatial diversity is employed by positioning two antennas diagonally on opposite sides of the antenna structure. RF power distribution and combining network is integrated on the PCB, with a single RF interface to an external radio transceiver. Analysis and design of the feed network for the antenna elements is demonstrated. Kim, G et al presents a dual polarized broadband microstrip patch antenna for a 5G mm Wave antenna module on an FR4 substrate. The proposed antenna was fabricated using a standard FR4 printed circuit board (PCB) process because of its low cost and ease of mass production. The electrical properties of the FR4 substrate in the 5G mm Wave frequency band were also characterized.

Antenna design plays a vital role in determining its performance. Micro strip patch antenna is simpler to construct as it provides easy feeding and has low profile when compared to other type of antennas. It has a patch supporting radiation, along with a ground plane and the substrate. In the proposed designs the ground plane is made of copper andFR4 material is used for making the substrate. The patch can be of any shape, here the shape of patch chosen to be rectangle instead of circular because it provides high gain. The antenna has slots within the patch and is provided with an inset feed.

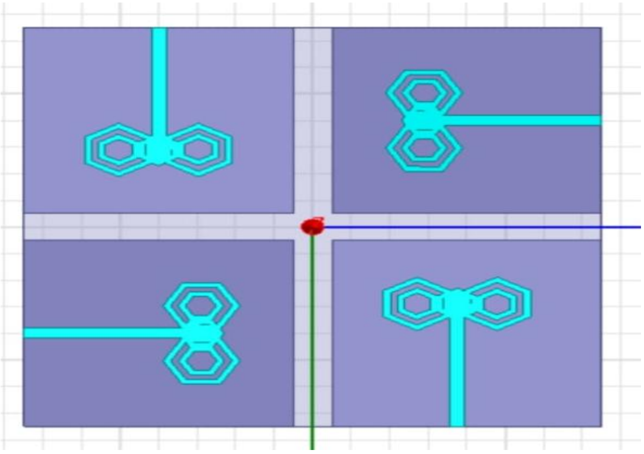

Figure 1 Proposed Antenna

The length and width of the ground plane are 65 × 27mm.The height of the substrate is chosen as 1.6 mm. The square patch dimensions are 65 × 27mm. The design includes the removal of square of unit size and circle of radius of 0.8 mm from the patch as shown in the figure. The slot width and length are 0.5 mm and 3.99 mm respectively. The overall length of the feed line is 26 mm as shown in Fig. 3. These design parameters are calculated using the above-mentioned formulae and the proposed antennas are connected with 50Ωtransmission feed line

Simulation Results

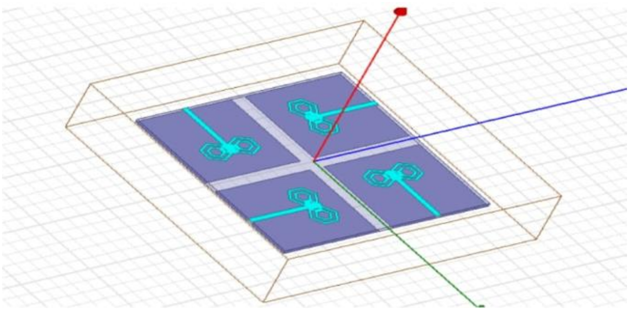

Figure 2 Proposed Structure

The above figure shows the radiating element design of proposed antenna. In radiator , the hexagon cuts are created to tuned for the required frequency . The radiator is formed a flexible substrate.

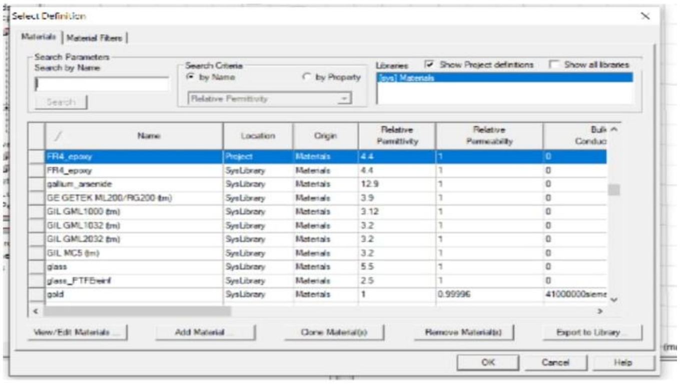

Figure 3 Material Design

The above figure shows jean substrate design for proposed antenna design. By using film technology, the proposed antenna mounted on FR4 substrate.

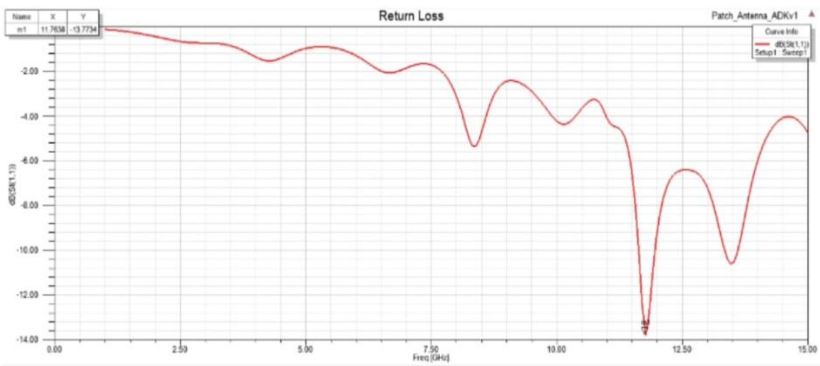

Figure 4 Return Loss

The above figure shows the return loss analysis of proposed antenna. The proposed antenna achieved a RL of -13 with the tuned frequency .The effect of creating various slots analysed for different cuts in a radiating elements.

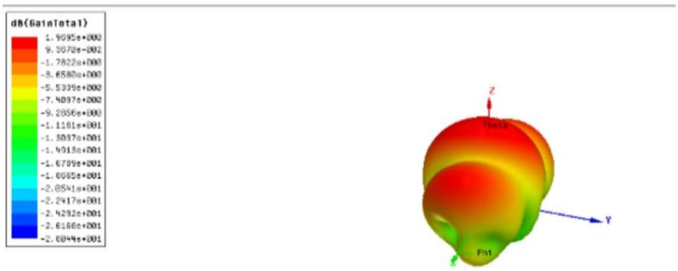

Figure 5 3D Gain

Figure shows the gain analysis of proposed antenna. The proposed model achieved a gain value of 9.3 for the tuned frequency. The average values of gain achieved about 9 in the FR4 substrate.

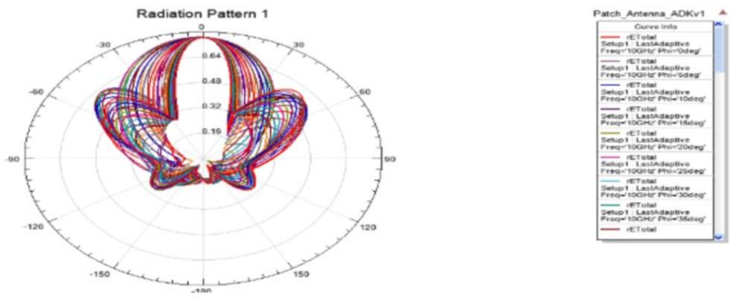

Figure 6 Radiation Pattern of Proposed Antenna

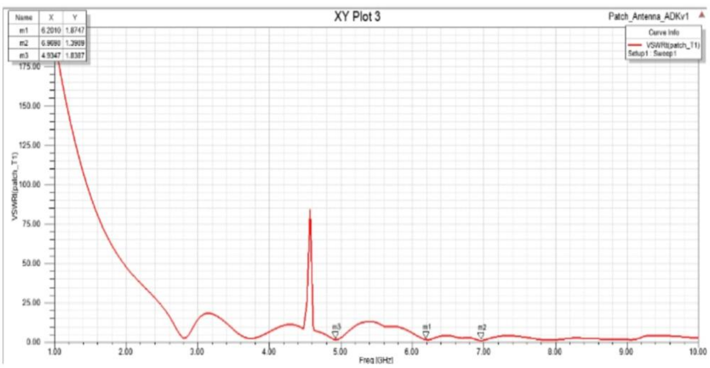

Figure 7 VSWR Measurement

Table shows the performance comparison of proposed antenna. Compared to other design, the proposed antenna shows higher gain, RL and VSWR results.

Table 1 Performance Comparison of Proposed Antenna

Parameter	Existing	Proposed
Gain	5.6	9.3
RL	-13	-20
Directivity	4.34	5.55
VSWR	1.5	1.57

Conclusion

In this work, compact and array antennas is designed. The proposed antenna system cover a wide range of frequency spectrum which covers all candidate frequencies considered for 5G communications. Although, antenna has good characteristics like light weight, wide bandwidth, easy to fabricate and stable radiation patterns. Though gain values were improved at the targeted frequencies with the eight elements antenna design but higher values were obtained by introducing frequency selective surface (FSS). A good agreement between simulated and measured results was noted. The proposed eight element array design is considered candidate antenna for 5G applications due to its wider bandwidth, stable radiation patterns, and higher gains at the targeted frequencies

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