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Design of E-Shaped Dual-Band MIMO Antenna for 5G Smartphone Applications

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***Abstract:** This chapter focuses on the design of E-shaped dual bandMIMO antenna intended for 5G mobile applications. It operating at 3.3 GHz and 32 GHz. The antenna designed in this letter are different from traditional 5G antennas, the antenna of this paper is perpendicular to the edge of the system circuit board, it can be applied to the popular full-screen mobile phone. The antenna was designed by using FR-4 substrate material with relative permittivity is 4.3 and it results Right hand Circular Polarization. Simulation has been realized using ANSYS HFSS Software.*
***Keywords:** FR-4 substrate, dual band, 5G antennas*

I. INTRODUCTION

Since the advent of mobile communication, the number of subscribers–and hence mobile devices–going online has witnessed an exponential increase, and the industry has responded by being innovative in the different aspects of wireless communication, as for instance transitioning from 4G to 5G networks. One of the key enabling technologies for bandwidth and speed enhancement technologies of 5G networks is the use of millimeter waves. While several bands above 6 GHz have received approval for 5G, to-date most of the research and development efforts have focused on the 28 GHz and 38 GHz [1-2].

In order to meet the needs of modern 5G wireless communication system, study of the 5G smartphone antenna has great application value. 5G has become a hot spot in the field of mobile communications both at home and abroad. In early 2013, the EU launched the METIS (mobile and wireless communications enablers for the 2020 information society) project for 5G in the 7th framework plan, China and South Korea set up IMT-2020 (5G) Propulsion Team and 5G Technology respectively. At present, various countries in the world are conducting extensive discussions on the development vision, application requirements, key technical indicators and enabling technologies of 5G [3-4].

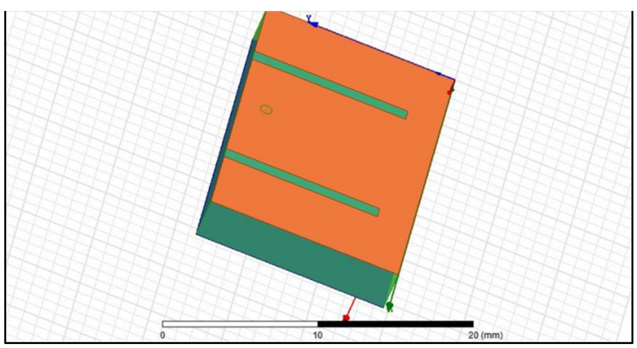

Figure 1.1: The proposed antenna structure

II. LITERATURE SURVEY

Hanseung Lee et al, represents a slot and surface mount technology (SMT) capacitors on the top metallic layer of SIW resonator provide necessary reactance to realize multi-resonance CRLH structure. Due to the intrinsic multi-band characteristic of a CRLH structure, the proposed antenna can provide dual-band broadside radiations. Polarization flexibility is realized by two orthogonal feed lines [5]. the proposed antenna supports negative resonant mode, which resonates at much lower frequency than that of the conventional TE120 mode for the same physical dimension. Therefore, in contrary to the previously proposed DBPF antenna that uses conventional TE120 mode for first broadside radiation, the proposed antenna behaves as an electrically miniaturized radiator.

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Ying Liu, Sihao Wang, Na Li, Jingbo Wang and Jianping Zhao suggested the method of dual-polarized symmetrical antenna with filtering structure The two operating bands are very close to each other (the center frequency of UB is 1.32 times of LB). By using the L-shaped and C-shaped filtering stubs to suppress the mutual coupling, high port-to-port isolation is achieved between LB and UB (> 25dB) [6]. Unlike the traditional dual band and dual-polarization antenna arrays, the proposed array is composed of four hybrid antennas (the UB element is nested in the LB element). The proposed antenna array solves a series of problems such as the large array width, asymmetric radiation pattern and insufficient isolation, in the case of two frequency bands are very close [6-8].

III. ANTENNA DESIGN

The E-shape rectangular patch can be designed by incorporating two parallel slots in the radiating patch. Here FR4 substrate is used for designing the antenna. It has a relative permittivity of 4.4, substrate thickness of 1.59 mm and loss tangent of 0.02. In this design, a new rectangular structure has been followed and the designed patch antenna length and width dimensions are 12.56mm x 17.56mm. The antenna design of main and near view as shown in the Figure 3.1 and 3.2. In order to calculate
The width we have to follow the following formulae

$$w = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

To calculate length we have to follow the following formulae

$$l = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{eff} - 0.258)(\frac{w}{h} + 0.8)}\right)$$

Where,

$$\varepsilon_{eff} = \frac{\varepsilon_R + 1}{2} + \frac{\varepsilon_R - 1}{2}\left[\frac{1}{\sqrt{1 + 12\left(\frac{h}{w}\right)}}\right]$$

The optimized substrate length is 48 mm and width is 50 mm. The length and width of E- shape radiating patch is 31 mm and 29.45 mm respectively. The slot dimension is 4 mm. The inner radius of the probe is 0.62 mm and outer radius is 2.35 mm. The location of the probe is (0,-11 mm). The proposed antenna is shown in Fig. 1.1 The top view and side view of the antenna is shown in Fig. 3.1 and 3.2.

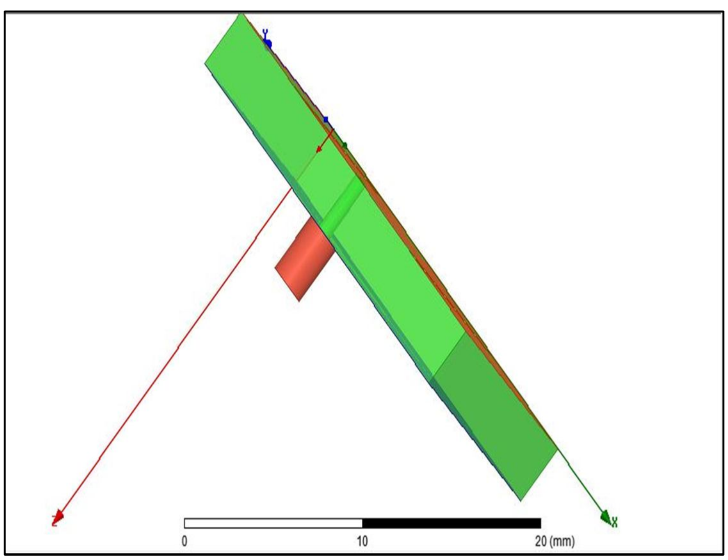

Figure 3.1: Antenna element model side view

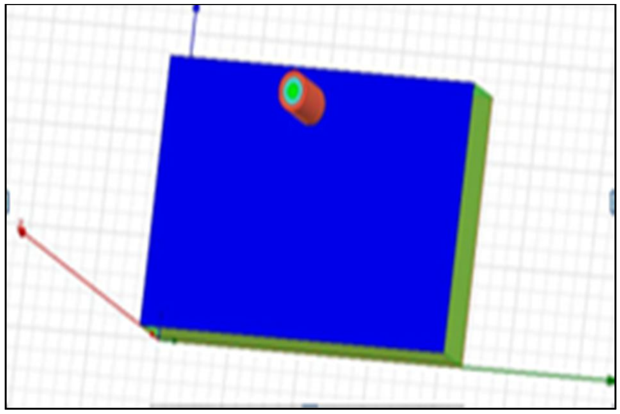

Figure 3.2: Antenna element model top view

IV. SIMULATED RESULTS

The designed antenna results was verified on HFSS (High Frequency Structural Simulator) based on Finite Element Method. The antenna which was designed to operate in the range that is (3.3-32)GHz.

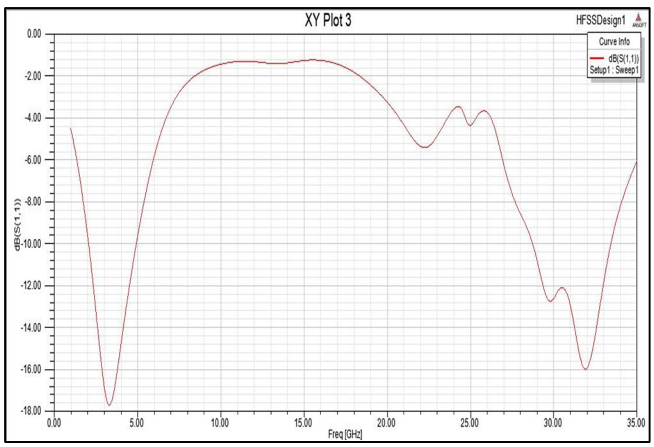

Figure 4.1: Antenna element model main view

The transmission coefficient between antennas are presented in Fig.4, it shows a dip (about -16 dB) at about 32 GHz and less than -17dB at about 3.3 GHz for frequencies in the operating band, which is acceptable for smartphone applications. For the antenna efficiency shown in Fig.4, it is all above 50% in the operation band,which is good for the MIMO operation. The result suggest that the proposed antenna are suitable for practical MIMO operation and can be used as a building block in forming the MIMO antennas in the future smartphones.

The Radiation Pattern of the designed antenna is as shown in Figure 4.2.

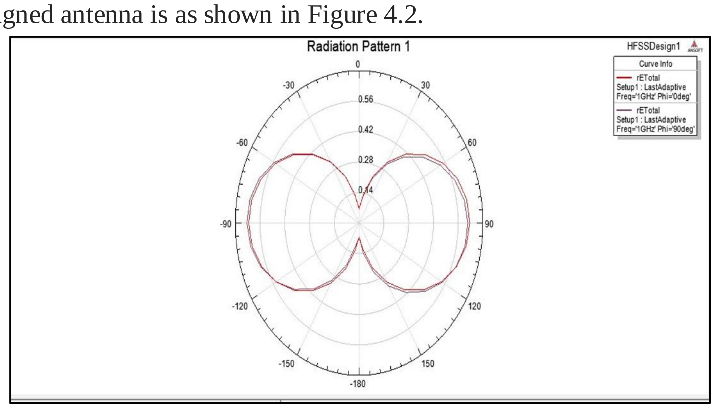

Figure 4.2: Radiation Pattern of Designed Antenna

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The Voltage Wave Standing Ratio of the designed antenna at 4.3GHz which is shown in Figure 4.3.

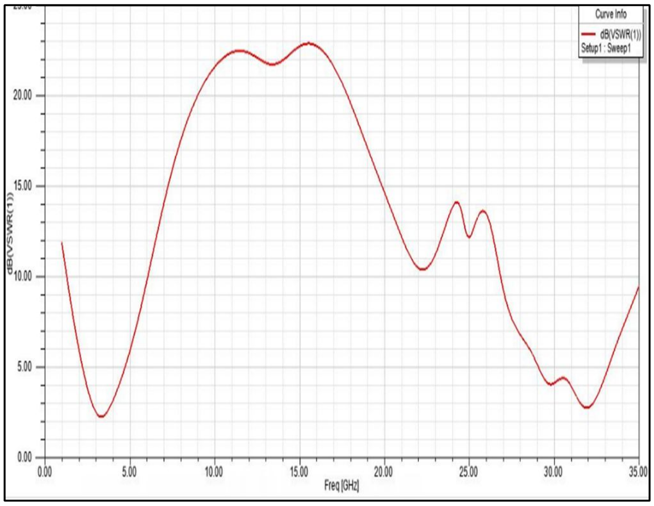

Figure 4.3: VSWR of the Designed Antenna

The electric field intensity of the designed antenna is as shown in Figure 4.4.

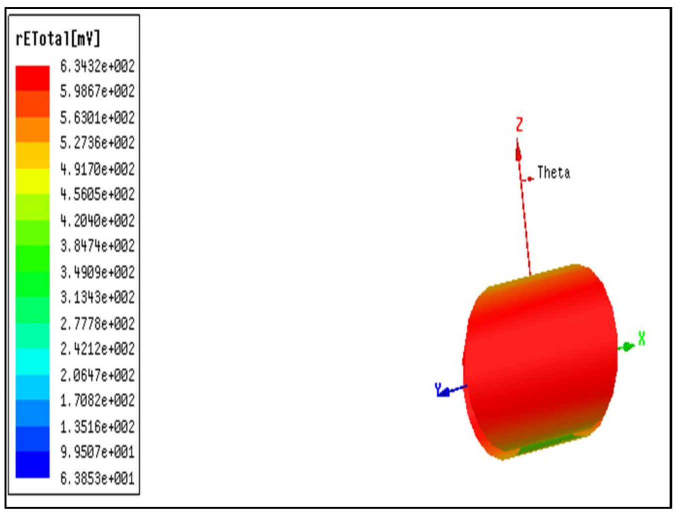

Figure 4.4: E-Field distribution of the Designed Antenna

The gain of the designed antenna is as shown in Figure 4.5, and it results a gain 9.7dB.

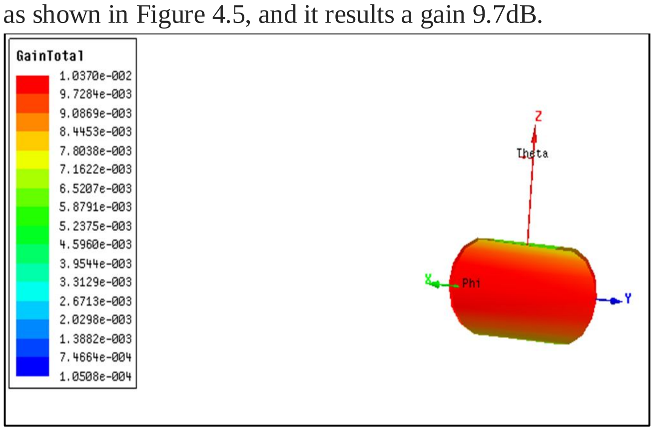

Figure 4.5: Gain of the Designed Antenna

V. ANALYSING RESULTS

A. Radiation Pattern

The simulated and measured radiation patterns of the 5G MIMO antennas at 25 GHz. It can be seen that the antennas demonstrate an approximately directional radiation pattern. A discrepancy has been observed between simulation and measurement patterns which may have incurred due to soldering of SMA connectors as the housing of the connectors extends outside ground boundary. This might have been avoided if pig-tail connectors were used.

B. Gains & Efficiencies

The gains and efficiencies of the MIMO antennas at different frequencies are shown in Figure 4.5. Gain is computed by the 'Gain comparison method' using standard gain Horn antenna, whereas, for the measurement of efficiency 'Wheeler Cap method' is used [10]. Some discrepancies have been observed between the simulated and the measured values which are mainly due to the imperfections in the fabrication of the antenna especially the flange connectors which extend outside ground boundary. The average difference between the simulated and measured gain of Antenna is 1.41 dB whereas, that for efficiency is 14.2 %.

C. Performance Comparison

The gain and efficiency performance of the MIMO antennas is better than most of the 8-Element MIMO antennas. Also, the design covers a smaller area than most of the designs which makes it distinctive and more suitable for small wearable and portable devices. Moreover, the MIMO configuration with E-shaped patch antennas is rare and will give a better capacity and throughput performance than the other 4-element and 8-element MIMO antennas in the literature.

VI. CONCLUSION

In this paper, the dual band E-shape antenna is reported. The unique design and shape of the antenna mainly serves the role of enhanced result. HFSS 13.0 simulator is used for simulating the characteristics of the proposed antenna. The simulated results represent the enhanced performance of the proposed antenna. The simulated result shows dual band operation in enhanced bandwidth and gain and lower VSWR. An improved VSWR of 4.3 is achieved for resonant frequency of 3.3 GHz. The gain value is9 dBachieved. Because of all of these merits, the proposed antenna can be widely used in modern 5G communication system.

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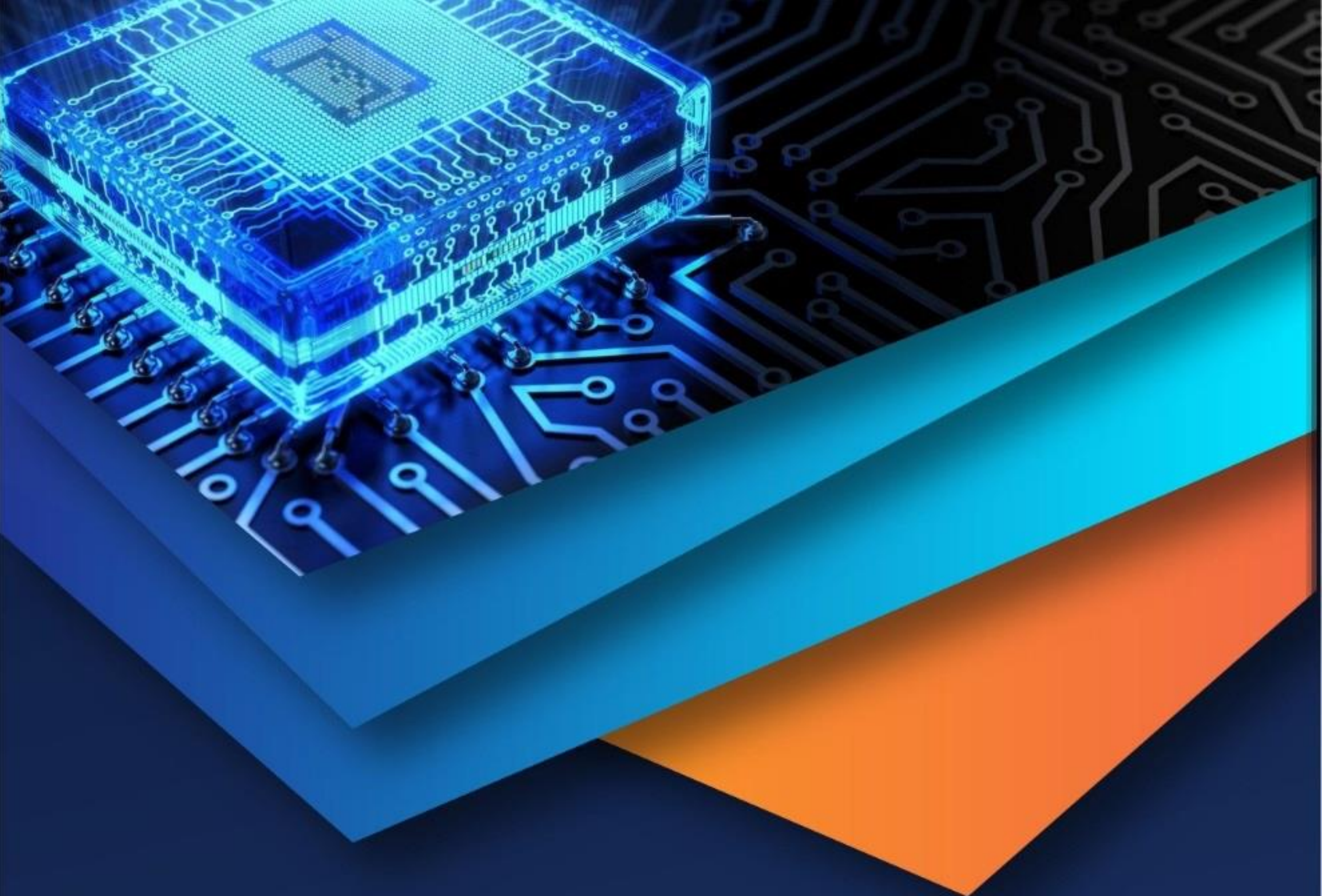

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