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# DESIGN OF A COMPACT MIMO ANTENNA FOR 5G APPLICATIONS IN SUB-6 GHZ BAND

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***Abstract:*** MIMO wireless technology can significantly improve the data rate and capacity of wireless systems through multipath data transmission and reception. MIMO systems are currently employed in 4G user equipment and show promise for use in future 5G mobile terminals. One of the promising frequencies, for sub-6-GHz MIMO 5G communications is 3.5, and 3.6 GHz, respectively. There are many requirements for antenna design, such as low-profile, bandwidth, ease of fabrication, and high isolation. To improve isolation and reduce mutual coupling between the adjacent microstrip-line feeding ports of the dual-polarized radiators, a pair of circular-ring/open-ended parasitic structures is embedded across each rectangular radiator. The size of the dual-polarized antenna is 25 × 25 × 1.6 $mm^3$, with an impedance bandwidth of each antenna element (2.4× 10 mm2) is 500 MHz (3.35–3.85 GHz) and a realized gain of 3.03 dBi. In addition, the Specific Absorption Rate (SAR) and the radiation characteristics of the proposed design in the vicinity of the user's head are studied. The proposed antenna exhibits good features with potential applications for use in 5G mobile terminals. The proposed MIMO antenna is designed and simulated using CST MWS 2019 software.

***IndexTerms* -** 5G, dual-polarized antenna, MIMO system, mobile terminal, slot antenna.

## I. INTRODUCTION

An Antenna is a transducer, which converts electrical power into electromagnetic waves and vice versa. An Antenna can be used either as a transmitting antenna or a receiving antenna. A transmitting antenna is one, which converts electrical signals into electromagnetic waves and radiates them. A receiving antenna is one, which converts electromagnetic waves from the received beam into electrical signals. In two-way communication, the same antenna can be used for both transmission and reception. Antenna can also be termed as an Aerial. Plural of it is antennae or antennas. Now-adays, antennas have undergone many changes, in accordance with their size and shape. There are many types of antennas depending upon their wide variety of applications.

In the field of communication systems, whenever the need for wireless communication arises, there occurs the necessity of an antenna. Antenna has the capability of sending or receiving the electromagnetic waves for the sake of communication, where we cannot expect to lay down a wiring system. In order to contact a remote area, the wiring has to be laid down throughout the whole route along the valleys, the mountains, the tedious paths, the tunnels etc., to reach the remote location. The evolution of wireless technology has made this whole process very simple. Antenna is the key element of this wireless technology. The sole functionality of an antenna is power radiation or reception. The functioning of an antenna depends upon the radiation mechanism of a transmission line. A conductor, which is designed to carry current over large distances with minimum losses, is termed as a transmission line. For example, a wire, this is connected to an antenna. A transmission line conducting current with uniform velocity, and the line being a straight one with infinite extent, radiates no power. If this transmission line has current, which accelerates or decelerates with a time varying constant, then it radiates the power even though the wire is straight. The device or tube, if bent or terminated to radiate energy, then it is called as waveguide. These are especially used for the microwave transmission or reception.

This can be well understood by observing the following diagram –

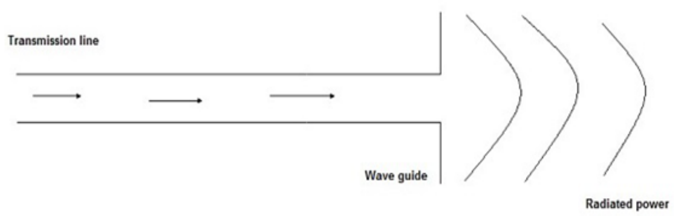


Fig. 1 A waveguide

The advent of 5G technology has brought about the need for advanced antenna systems to cater to the high data rates and diverse applications of 5G Smartphone. Dual-polarized Multiple-Input Multiple-Output (MIMO) slot antennas have emerged as a promising solution due to their compact size, high efficiency, and ability to support multiple-input multiple-output communication in 5G networks.

Research has explored the use of metamaterial structures to enhance the performance of dual-polarized MIMO slot antennas. Metamaterial-inspired designs offer improved bandwidth, isolation, and efficiency. Techniques such as meandering slots, fractal geometries, and compact feeding networks have been employed to miniaturize antenna size while maintaining performance. Studies have focused on integrating dual-polarized MIMO slot antennas seamlessly into 5G Smartphone platforms, considering factors such as antenna placement, coexistence with other components, and manufacturability. Despite significant progress, challenges remain in achieving wideband operation, compact integration, and mitigating mutual coupling and interference in dual-polarized MIMO slot antenna systems. Future research directions may include exploring advanced materials, novel feeding techniques, and adaptive algorithms to address these challenges and further enhance the performance of antenna systems for 5G Smartphone. Recently, several works were reported in the literature for 5G mobile terminals. However, all these antennas either provide narrow impedance bandwidth or use multiple radiators with single-polarization at different sides of PCB which occupy a huge space or increase the complexity of the MIMO system. A multiple-antenna design for 5G Smartphone applications is proposed in which is only covering 3.5 to 3.7 of 5G bands and also the maximum mutual coupling of the antenna elements is -10dB which could affect wireless system performance, antenna efficiency, as well as amplitude and phase of the radiators. Gap-coupled loop antenna array design with an impedance bandwidth of 3.4-3.8 GHz has been proposed in for the future Smartphone application. A four-port MIMO antenna with dual-polarized function has been proposed for 5G Smartphone Applications. Its bandwidth is very narrow and not wide enough to cover more than 100 MHz. In addition, the radiators of the antenna cannot cover both sides of the mobile-phone PCB, since they are patch antennas

## II. LITERATURE SURVEY AND DRAWBACKS

**Table 1 Comparative Analysis of the proposed antenna with the reported antennas**

| Ref. | Size of Antenna element (W × L) (m2) | Operating Band (GHz) | Bandwidth (MHz) | S21 (dB) | Avg. Realized Gain (dBi) | Radiation Efficiency (%) |
|---|---|---|---|---|---|---|
| [10] | 0.8 × 12 | 3.4-3.6 | 200 | -17 | NR | 51-74 |
| [11] | 1.5 × 11.5 | 3.4-3.8 | 400 | -15 | NR | 42-65 |
| [12] | 0.5 × 10 | 3.4-3.6 | 200 | -17 | NR | 50-60 |
| Base paper | 3 × 11.75 | 3.4-3.8 | 400 | -26 | 3 | 75 |

DRAWBACKS

1. One of the biggest disadvantages of Massive MIMO is the cost associated with its implementation and deployment.

2. The systems are several times more extensive than traditional base station units and antenna technologies. Furthermore, the design of multiple antenna systems for cellular networks is more complex and requires more effort and time during assembly and installation.

3. This phenomenon transpires when a receiver sends out feedback signals to a transmitter.

4. Increasing the antenna elements results in a further increase in the overhead.

## III. PROPOSED TWO PORT ANTENNA

The 3D view of the proposed four port antenna is displayed in Fig. 4.6. The proposed design is arranged on an FR4 dielectric with permittivity 4.3 and loss tangent 0.025 which has an overall dimension of 25 × 60 mm2. The dual-polarized square-ring slot antenna elements with the reduced size of 25 × 25 mm2 are placed at the corners of the smartphone PCB. The simulated S-parameters including the reflection coefficient (Snn) and the mutual coupling (Snm) characteristics of the designed dual-polarized MIMO antenna array are shown in Fig. 4.7. Clearly, the radiation elements have similar return loss performances providing high impedance matching (around -18 dB reflection coefficients) at 3.6 GHz.

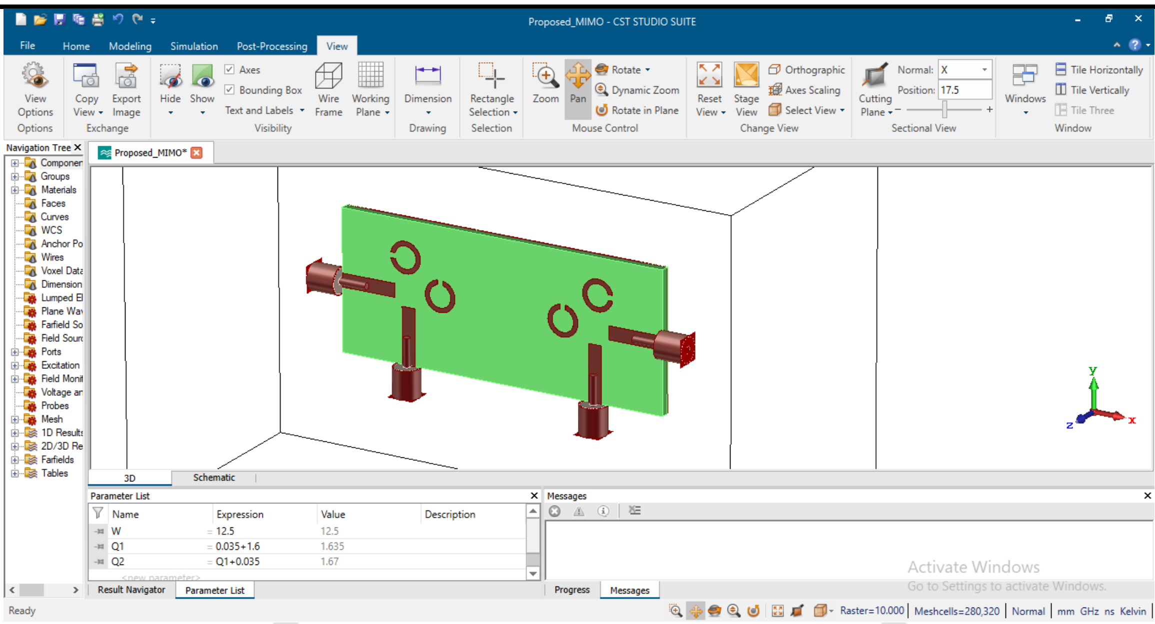


Fig.2 Design model of the proposed four port antenna

## IV. RESULTS AND CONCLUSION

The mutual coupling function of the antenna elements (less than −15 dB) are good enough to avoid the loss of radiation performance for the 5G smartphone antenna. Employing the slot radiators on the proposed 5G array configuration not only exhibits sufficient bandwidth but also provides almost symmetrical radiation patterns to cover the top and bottom regions of the PCB. As shown in Fig. 4.8, and 4.9, the antenna elements can provide high directivity radiation patterns covering the top and bottom sides of PCB and improving the coverage efficiency function.

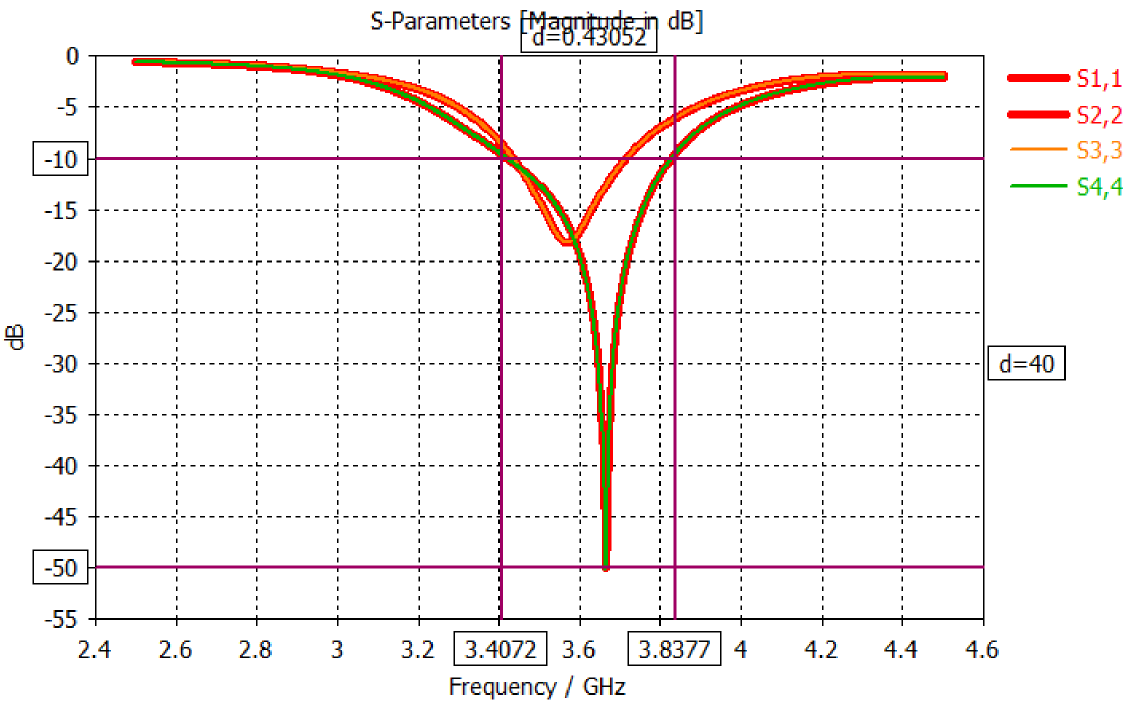


Fig. 3 S11-parameter plot of the proposed four port antenna

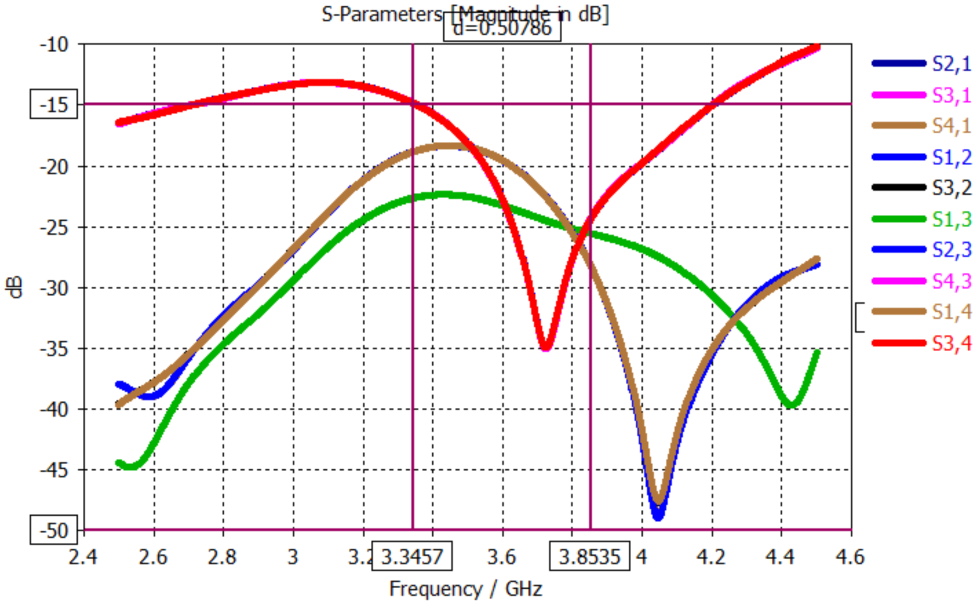


Fig.4 S21-parameter plot of the proposed four port antenna

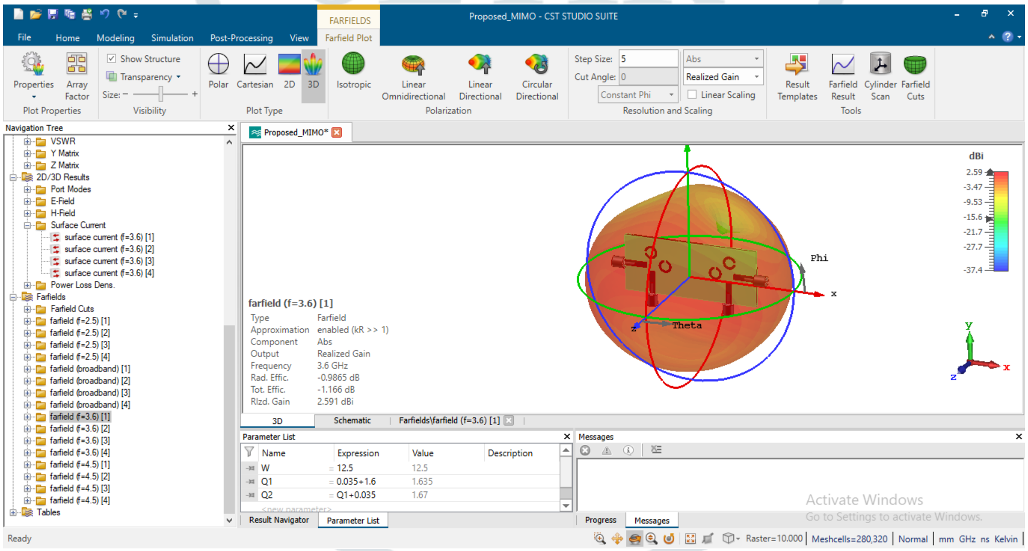


Fig. 5 Realized Gain of the proposed four port antenna at 3.6 GHz

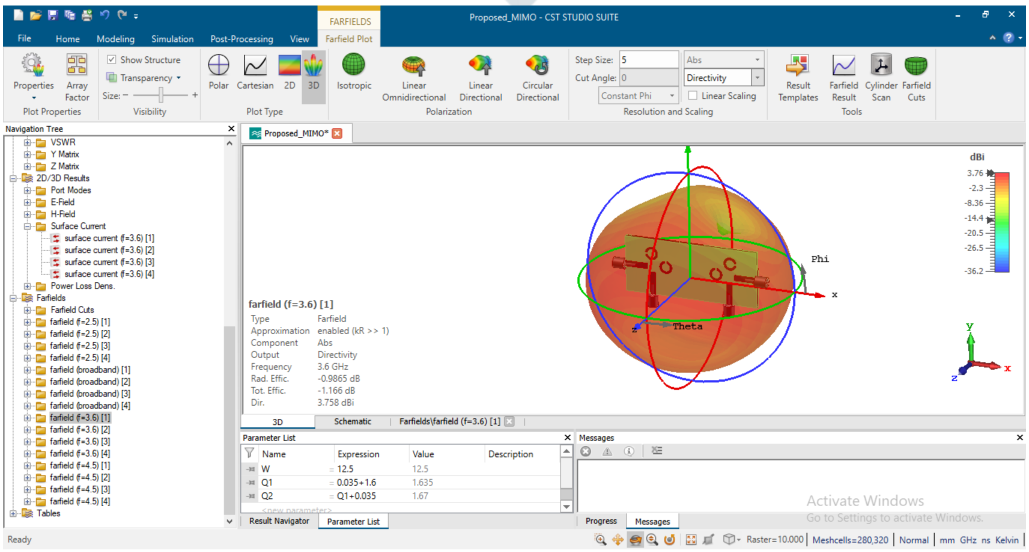


Fig. 6 Directivity of the proposed four port antenna at 3.6 GHz

**CONCLUSION**

Based on the simulation and measurement results, it can be concluded that, the proposed antenna has a compact size with a simple configuration, and it operated at 3.6 GHz, which covers (3.35–3.85 GHz) band with radiation efficiency of 83.2%, and high level of impedance matching, where VSWR is less than 2 and the return loss is better than -10 dB. Therefore, the proposed slotted antenna can be operated with good performance at the desired band (3.35–3.85 GHz), and it can be used properly for 5G smart watch applications.

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