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Modern 5G MIMO Antenna for Vehicular Communication and Safety

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Abstract

A Modern 5G Multiple Input Multiple Output(MIMO) antenna alignment with frequency range for the 5G NR-n2 band (1.81 GHz) and protection band (5.85 GHz) that are dual-band for automobile communication and safety is offered. In a relatively shrunken dimension in relation to its working wavelength, the smallest frequency of resonance is relatively challenging to attain. The antenna's dimensions are 60mm× 60mm × 1.6mm and it achieves a gain of 4.65 dBi and 3.38 dBi, at the frequency range of 1.81 GHz and 5.85 GHz. Because of the presence of ground slot, MIMO antennas offer isolation values of more than 19 dB and diversity gains that are comparatively close to 10 dB.In GSM and safety applications, this enhanced square single-element and MIMO antenna offers a noticeably increased gain and improved performance. The on-vehicle study of MIMO setups is performed to ensure the durability of the specified antenna in an automotive application.

Keywords: MIMO, Radiator, Isolation.

Introduction

Micro-strip patch antennas are a type of antenna that is widely used in modern communication systems. They consist of a thin, flat rectangular metal patch that is mounted on a ground plane and fed by a coaxial cable or other transmission line. The patch is usually made of conductive material such as copper or aluminum and is typically only a few millimeters thick. Micro-strip patch antennas are popular because they are lightweight, low profile, and easy to manufacture using printed circuit board (PCB) technology. They may be made to work across a wide range of frequencies and be applied to a variety of devices, including satellite-based communications and smartphones, and wireless local area networks (WLANs).

In order to satisfy the needs of the modern 5G wireless communication system, the research investigation of the 5G smart phone antenna has substantial application benefits. Both domestically and internationally, 5G has emerged as a hot topic in the world of mobile communications. The EU started announcing its METIS in 2013.

High-performance antennas can be used in various applications where reliable wireless communication is required. In broadcast applications, high-performance antennas are used to transmit and receive radio and television signals over long distances with minimal interference. In eyewear applications, antennas can be integrated into smart glasses or other wearable devices to enable wireless connectivity for data transfer or communication purposes. The performance of an antenna depends on various factors such as its design, frequency range, gain, radiation pattern, and impedance matching. By optimizing these parameters, it is possible to achieve high performance in different applications [3].

The development of the 4G mobile communication technology has increased demand for fast mobile communication. In order to meet these objectives, the fifth generation (5G) antenna has been studied and built. [3-5].

Multi-mode antennas are becoming increasingly important in modern communication systems as they can support multiple frequency bands and standards, enabling seamless connectivity between different networks. By using a multi-unit antenna design, it is possible to achieve higher gain and radiation efficiency compared to a single-element antenna, which can improve the overall performance of the system.

A single 3.5GHz band is occupied by an 8-element planar inverted F type Antenna (PIFA) based MIMO antenna system that was presented in [7]. To keep up with the needs of a full-screen smartphone antenna design and in line with the current vogue of full-screen smartphones, the four antennas are positioned across the device's two side edges. Additionally, this proposed antenna achieves a higher isolation of 24 dB between its multiple elements compared to the previous design presented in [7].

Antenna Design

In this paper for antenna designing the flame retardant (FR4) substrate material is made from a flame retardant epoxy resin and glass fabric compositewith a thickness of 1.6 mm is used as shown in Fig1. The dimensions of the antenna are 60mm x 60 mm. The CPW (co-planar wave guide) technique is used to fed the antenna.

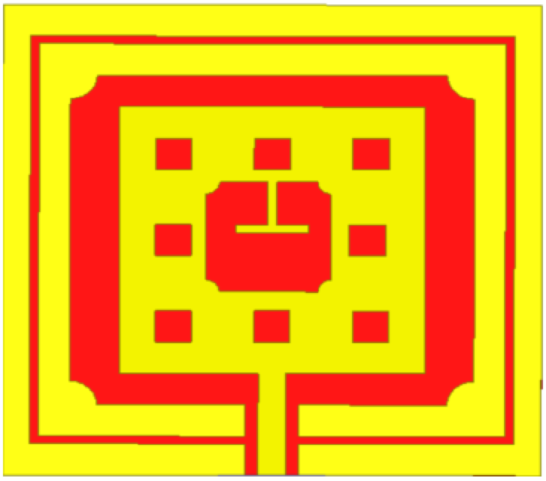
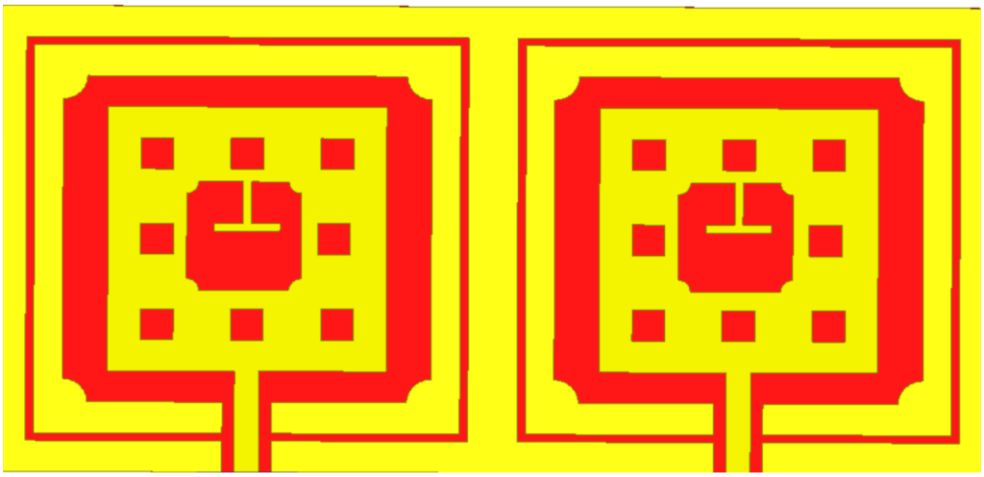


Fig: Single radiating antenna structure

Proposed MIMO Antenna Design



Calculation of the patch length and width

The dimensions of the Micro-strip patch is given by

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

Where,

h = height of the substrate (FR4)

r and h are dielectric constants

f_r is the frequency of operation

Return Loss is given by

Return Loss (dB) =10 log10 (pi /pr)

According to the reflection coefficient, the Return loss equation is:

Return loss = -20 x log [mag (Γ)]

Results

Return loss

Return loss is the reduction in signal power brought on by reflection at a transmission line break.

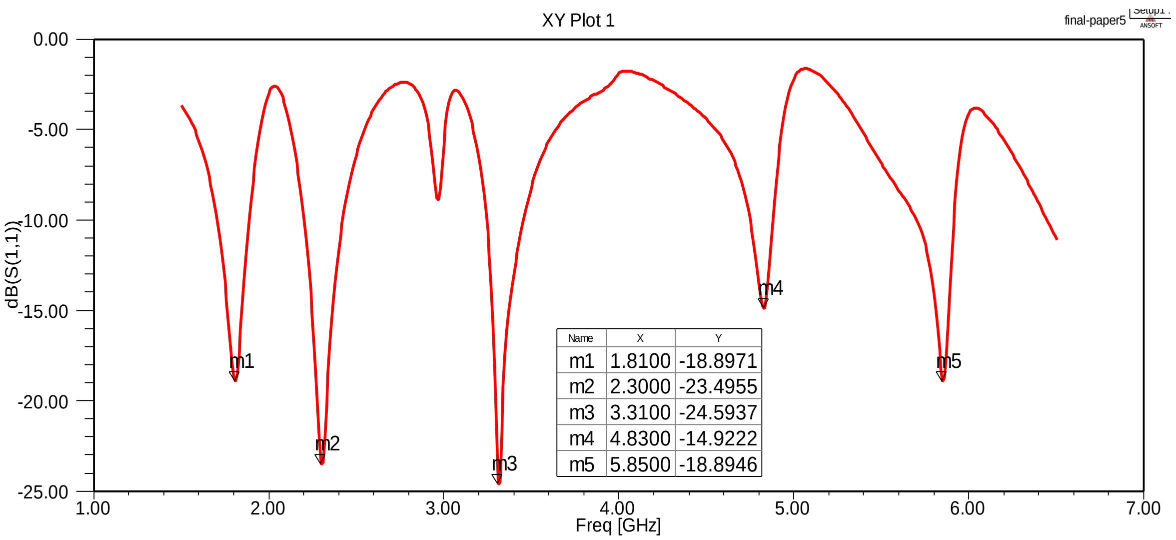
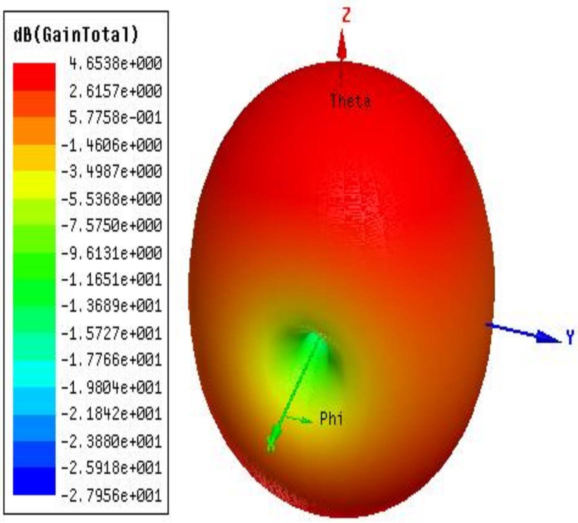
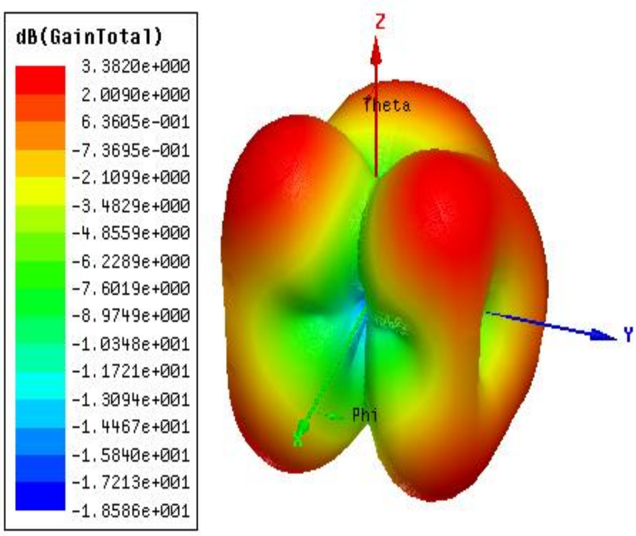


Fig:Return loss -18dB at 1.81GHz & -18dB at 5.85GHz

Antenna gain

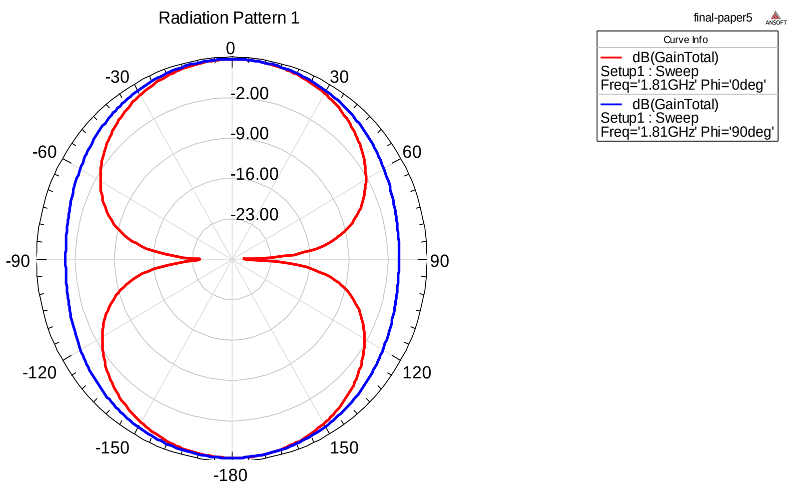
Antenna gain is a measure of the ability of an antenna to direct or concentrate the radiated power in a particular direction. It is described as the ratio between the intensity of the radiation in one direction and the level of intensity that would be attained if the power had been distributed evenly across the entire spectrum.The gain of an antenna depends on various factors such as its physical size, shape, and design, as well as the frequency of operation. By optimizing these parameters, it is possible to achieve higher antenna gain, it can enhance a communication's overall performance system by increasing its range and reducing interference.



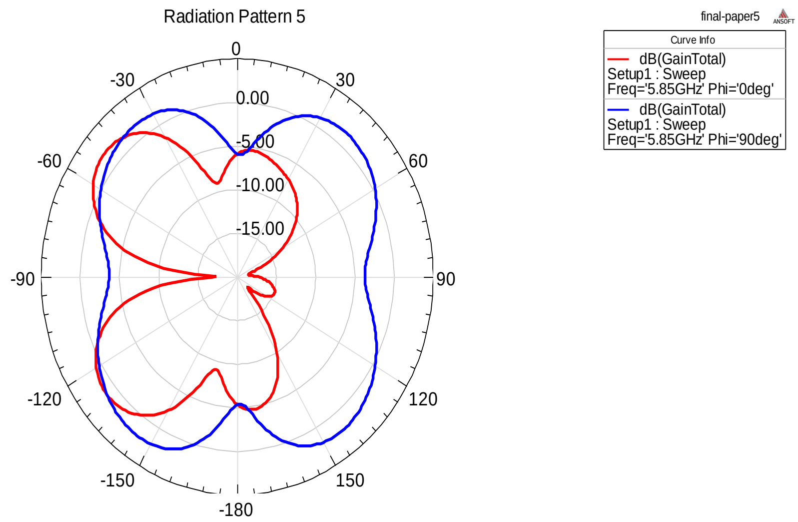


At 1.81GHz **At 5.85GHz**

Radiation pattern

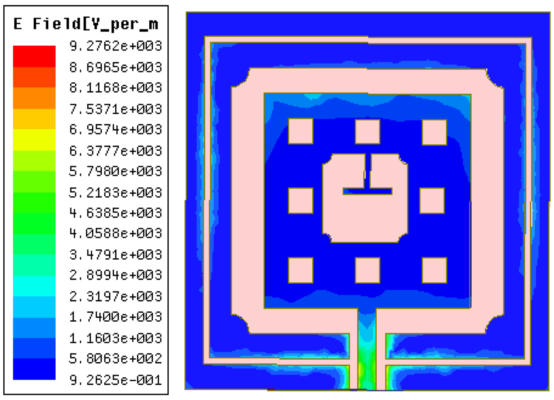


At 1.81GHz

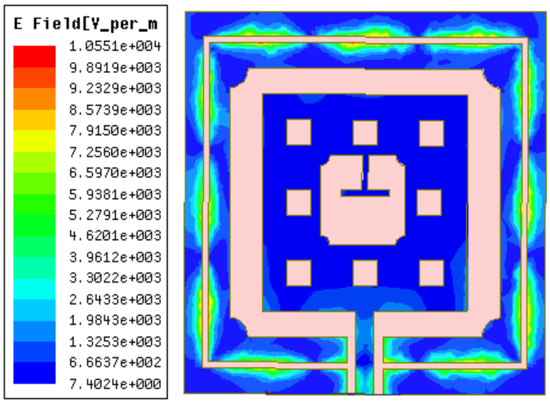


At 5.85GHz

Electric field distribution



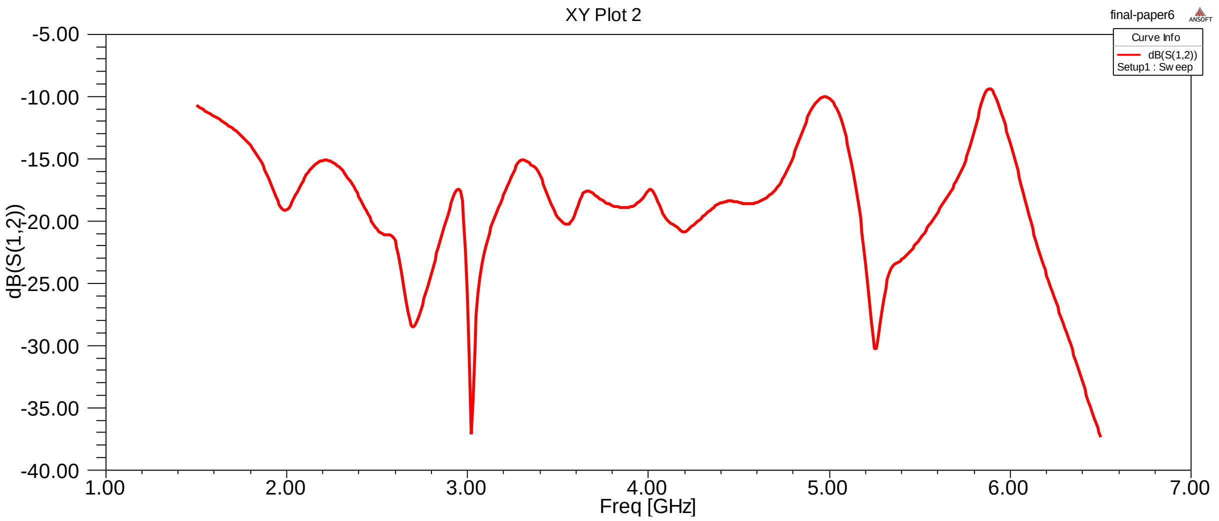
At 1.81GHz



At 5.85GHz

Mutual coupling

Mutual coupling is an important factor to consider in MIMO antenna design as it can affect the performance of the antennas and the overall system. Mutual coupling refers to the interaction between two or more antennas that are placed close to each other, which can cause changes in their impedance, radiation patterns, and other characteristics. To minimize mutual coupling effects, various techniques such as decoupling networks, isolation structures, and antenna placement optimization can be used.



Conclusion

Thus,a modern 5G Multiple Input Multiple Output(MIMO) antenna alignment with frequency range for the 5G NR-n2 band (1.81 GHz) and safety band (5.85 GHz) that are dual-band for automobile communication and security is offered. In a relatively shrunken dimension in relation to its working wavelength, the smallest frequency of resonance is relatively challenging to attain. The antenna's dimensions are 60mm× 60mm × 1.6mm and it achieved a peak gain of 4.65 dBi and 3.38 dBi, at the frequencies of 1.81 GHz and 5.85 GHz. Because of the presence of ground slot, this MIMO antenna offers isolation value 19 dB and diversity gain 10 dBIn GSM and safety applications, this enhanced square single-element and MIMO antenna offers a noticeably increased gain and improved performance. The on-vehicle study of MIMO setups is performed to ensure the durability of the specified antenna in an automotive application.

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