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Designing A Metamaterial Inspired Mimo Antenna For Multi-Band Application

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Abstract: creating a novel MIMO antenna with two elements that can operate in different bands. This study's design of an ultra-wideband and multiple band antenna was suggested along with an analysis of its characteristics. To accomplish the downsizing and performance of the two antennas, an isolation approach using well-designed metamaterials is proposed. The metamaterials employed significantly minimise the coupling of multi-antennas. Split-ring resonator (SRR) materials have been used to the antenna patch plane, which has improved the antenna's performance in terms of S parameters, multiplexing effectiveness, diversity gain (DG), radiation characteristics, and envelope correlation coefficient (ECC). To reduce the isolation between dual components, a novel decoupling structure has been studied and developed between the two antennas. The transmission rate is raised as a result. This antenna system has benefits including reduced weight and thickness, which makes it easier to integrate it into a receiver designed specifically for mobile communication. Using Computer Simulation Technology (CST), the antenna was tuned for 2-18 GHz with a permittivity of 2.2 and a thickness of 1.57 mm on a FR-4 substrate.

Keywords— Diversity Gain, ECC, metamaterials, mutual coupling, UWB-MIMO antenna

1. INTRODUCTION (*Heading 1*)

Mobile communications of the fifth generation (5G) are already being used in applications. Mobile communication systems have been using multiple-input multiple-output (MIMO) technology to increase the speed of data transfer. In the constrained area, a mobile terminal must be placed with an extra eight or more 5G sub-6 GHz band antenna components. Designing a MIMO antenna with a wide working spectrum and a compact size is crucial. The 2G/3G/4G antennas of a mobile phone are typically found on top or at the bottom of the device, according to research conducted in the past [1]–[4] and in real-world applications. The two long edges of a mobile phone are where 5G antennas are mostly placed in order to be compatible with 2G, 3G, and 4G antennae. [5]-[11].

The traditional MIMO antenna design [5]–[7] places several separate components along the long edges of a mobile phone. MIMO antennas take up a lot of space along the long sides of a mobile phone since the components must be separated by great distances in order to have appropriate isolations. A few antenna pairs are suggested to create small 5G MIMO antennas to address this issue [8]–[11]. The overall installation area of the MIMO antenna is decreased since the two pieces of an antenna pair have a close proximity to one another. A small self-decoupled antenna pair is suggested in [8]. The mutual connection of the two neighbouring components is lessened by a grounding branch.

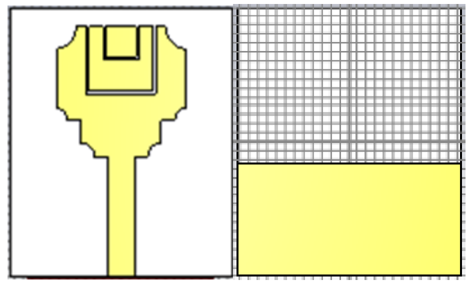
In this study, we suggest a UWB antenna that operates in the [2]-[18] GHz band and has an efficiency of more than 70% and a gain of between 2 and 6.5 dB. The measurements of the reflection parameter S11 at the antenna's input are found to be in excellent agreement with the calculations. The next solution we suggest has two very near antennas that are separated at /12. The impact of mutual coupling may be reduced down to 35 dB at 7.8 GHz with an isolation gain of 20 dB when 5 SRR cells are introduced and placed linearly between the two radiating components. This is in comparison to two antennas without SRR. The transmission parameter S21 is the subject of a comparison between models and observations in this research. As a result, it can be seen that the proposed UWB-MIMO multi-antenna system is a strong contender for future wireless communication technologies like 5G and connected objects.

2. DESIGN OF THE STRUCTURE

The square-shaped microstrip patch antenna design was created using the microstrip line feed technology and the dimensions shown below. The design process is provided, and the electric field distributions on the radiating patches are analysed, to help understand how the suggested MIMO antenna functions. Software for computer simulation technology (CST) is used to model the layout. Figure depicts the schematic for the modified square patch antenna with partial ground.

TABLE 1. *Basic microstrip line parameters*.

Parameter	***W***	***H***	***εr***		***T***
Value	3.02mm	1.6mm	4.4mm		0.035mm



(a) (b)

FIGURE 1. *The proposed antenna: (a) front view, (b) bottom view*.

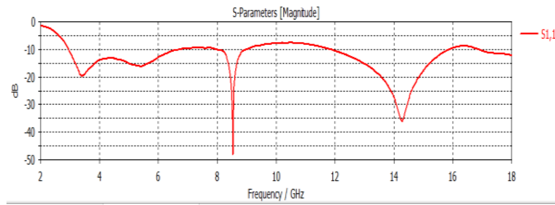
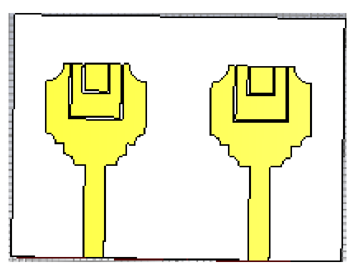


FIGURE 2. *Reflection coefficient as a function of the frequencies of the basic square antenna*.

Mutual coupling, which primarily results from the lower space between the parts, is the primary design criterion for MIMO system engineers when constructing compact electronic modules. However, compared to a SISO (Single Input Single Output) system, the design difficulties are more challenging when several antennas are used at tighter intervals. The mutual coupling of a MIMO system mostly relies on the separation of its components. Mutual coupling may be decreased by extending the space between antenna components. The spacing between the components cannot be kept too wide, however, since MIMO systems have many mobile applications where miniaturisation is crucial.

The suggested antenna is made up of a modified square patch, a portion of a ground plane, and a dielectric substrate made of FR4 epoxy with a permittivity of 4.4 and a thickness of 1.6 mm. Figure 4 illustrates a triangular entrance with a rectangular notch at ground level. A microstrip wire with a typical impedance of 50 ohms feeds this antenna.



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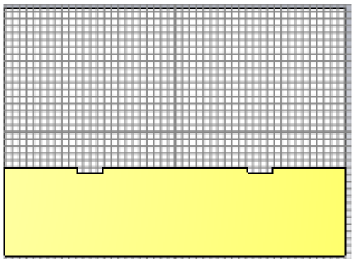

(b)

FIGURE 3. *The proposed MIMO antenna: (a) front view, (b) bottom view.*

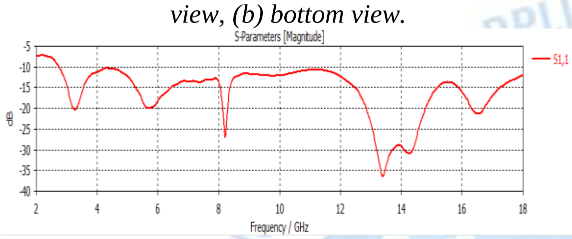

FIGURE 4. *Reflection coefficient as a function of the frequencies of the propsed antenna.*

Because of the MIMO antenna's benefits, particularly for large capacity and high speed wireless communication, researchers have concentrated on it [1]. Additionally, the need for MIMO antennas has grown in the current era to accommodate the expanding number of gadgets that need internet usages for 5G technology [2]. As a result, it is necessary to construct a small antenna with several input and output channels. The optimum antenna arrangement for 5G is MIMO since it satisfies all the standards. Reducing reciprocal coupling is the primary design problem for MIMO antennas [12].

By increasing the distance between the antennas, which is the conventional approach to reducing mutual coupling, the antenna's overall size will be increased. A technique for lowering mutual coupling between antennas is decoupling structure.

Due to its exotic material properties like negative refractive index, negative permeability, and negative permittivity can be exploited to obtain unusual physical effects and devices thereof for instance, negative refraction, super lens, super prism, cloaking etc. The novel structure of Split Ring Resonator (SRR) is used as the decoupling structure.

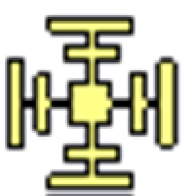

FIGURE 5. The novel SRR structure

By using the decoupling structure, the antenna bandwidth has been improved tremendously to 20.8%. The antenna has been printed with partial copper ground on the bottom layer.

COMPARISON AMONG THE PRESENTED MIMO ANTENNA AND THE PREVIOUSLY REPORTED UWB-MIMO ANTENNAS

S.No	***Existing work***	***Proposed work***
Element Number	2	2
Bandwidth (GHz)	2-18	2-18
Dimension (mm*mm)	50*40	48*35
Gain(db)	2-8	9-10
Radiation Efficiency	85%	88%
ECC	<0.07	<0.02

3. CONCLUSION

By using a modified square microstrip patch antenna with a modified SRR structure and a smaller substrate, we were able to obtain a gain of between 9 and 10 db with an ECC of less than 0.02. The FR-4 substrate is the one employed in this experiment, and the frequencies acquired for measuring the return loss value, VSWR, and Z parameter at six resonant frequencies below -10 dB are 4.2 GHz, 5.2 GHz, 7.5 GHz, 8.3 GHz, 13.5 GHz, and 16.7 GHz. The radiation pattern is also acquired for 360 degrees in both the E-plane and the H-plane. The gain is the primary factor in antenna design, and the suggested antenna's gain is improved. Multiple applications, including WLAN, WiMAX, radio communication, and satellite communication at frequencies of 4.2 GHz, 5.2 GHz, 7.5 GHz, 8.3 GHz, 13.5 GHz, and 16.7 GHz, respectively, were successfully implemented using the suggested antenna. The gain and return loss are enhanced using the proposed patch antenna.

4. FEATURE WORK

To fulfil the growing demand for wireless communications, researchers from all around the globe are attempting to create new technologies. The research project has shown examples of small antenna prototypes. To boost the gain for high-quality communication, further work may be done to evolve a modified square microstrip patch antenna into a triangular-shaped patch antenna with a modified SRR structure.

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