International Journal of Recent Advances in Multidisciplinary Topics
Volume 4, Issue 5, May 2023
https://www.ijramt.com | ISSN (Online): 2582-7839

MIMO Antenna for Wireless Applications

Sirigiri Sravani[1], M. G. Supriya[2], Srinidhi Gudi[3], Sushant Gupta[4*], V. R. Anitha[5]
[1,2,3,4,5]*Department of Electronics and Communication Engineering, BMS Institute of Technology and Management, Bengaluru, India*

***Abstract*: MIMO antenna is currently the focus of a lot of research because of its potential to increase the capacity and dependability of the wireless communication system. Despite the advantages, mutual coupling still presents a significant obstacle. Mutual coupling is normally undesired because it has an impact on the MIMO antenna and antenna array system's performance. By increasing mutual coupling, envelop correlation coefficient, channel capacity loss, diversity gain, and radiation pattern distortion, the interaction of the array elements and MIMO elements reduces system performance. When antennas are put close together, this issue could occur. A MIMO antenna has at least two radiating elements that are evenly spaced apart in order to achieve good isolation between them. But practical portable gadgets cannot fit in the space that is provided. Numerous methods have been used to reduce the mutual coupling between MIMO elements in this regard. The isolation in the suggested design is accomplished by sandwiching a number of metamaterial unit cells between the two antennas. Very little mutual coupling (|S21/S12| 20 dB) characterizes the proposed antenna. Considering that it has a low ECC, high diversity gain, high peak gain, low channel capacity loss, and the majority of importantly, its extremely high isolation, the proposed MIMO antenna is well-suited for the diverse wireless application possibilities.**

***Keywords*: MIMO, Patch antenna, S parameter, Mutual coupling.**

1. Introduction

The coupling of Closely spaced microstrip patch antenna connection elements is reduced using a metamaterial construction. Having an edge-to-edge separation of 7 mm, the two-element Multiple Input Multiple Output (MIMO) Antennae are close together. By preserving the metamaterial structure between the MIMO elements, an improvement in isolation of 9 dB is achieved. An isolation of about -24.5 dB is attained with the suggested configuration. The suggested antenna is an excellent choice for MIMO applications because of its low ECC, high gain, minimal channel bandwidth loss, and extremely low inter- element coupling. The suggested antenna has been made and put through testing. The simulation's outcomes and the measurements show a respectable level of agreement.

2. Objectives

- Good radiation pattern and return loss.
- Considering that it has a low ECC, high diversity gain, high peak gain, low channel capacity loss, and the majority of importantly, it's extremely high isolation, MIMO antennas are highly suited for the wide range of wireless applications

3. Literature Review

A literature review is an overview of the body of work pertinent to a certain topic or issue. It includes a summary of what has been said, names of important authors, prevalent theories and hypotheses, and procedures and methodologies that are acceptable and helpful. Before beginning the project and knowing the many methods that have been employed in the past, research is conducted in this chapter. The current systems underwent a thorough analysis. This analysis made it easier to determine the advantages and disadvantages of the current systems. Because of its potential to increase the capacity and dependability of the wireless communication system, MIMO antenna is currently attracting a lot of attention. Despite its advantages, mutual coupling is a significant obstacle that must be addressed. Since mutual coupling has an impact on the MIMO antenna and antenna array system's performance, it is normally undesired. Through increased mutual coupling, increased envelop correlation coefficient, increased channel capacity loss, decreased diversity gain, and altered radiation pattern, the interaction between the array elements and MIMO elements reduces system performance [1]. The presence of adjacent antennae may cause this issue. In order to achieve good isolation between them, MIMO antennas contain at least two radiating elements that are separated apart. However, there is not enough room for useful portable devices. Numerous methods have been used in this regard to reduce the mutual coupling between MIMO parts. The mutual coupling of the MIMO elements was reduced in [2] by inserting F-shaped stubs between the two radiators. In [3], neutralization line is used to achieve very low mutual coupling between the MIMO antennas. To improve isolation between the radiators, other strategies have been put forth in the literature. A meandered line resonator is introduced between the MIMO antenna's radiating elements [4], various elements are used for polarization diversity [5], electromagnetic bandgap structures are used [6]–[8], a U-shaped radiator is used [9], and a flawed ground structure is used [10]. By placing an extended T-shaped stub between the two resonators, coupling between eye-shaped MIMO antennas is lessened [11]. Below the V-shaped patches in [12], Artificial Magnetic Conductor (AMC) is employed to produce high gain, smaller size, and greater isolation. In order to reduce coupling, a new shaped decoupling structure is added between the radiating elements with an inverted F shape in [13].

*Corresponding author: sushantgupta2106@gmail.com

A mimo antenna in the shape of a lotus was built in [15] with isolation of 16 dB.

4. Methodology

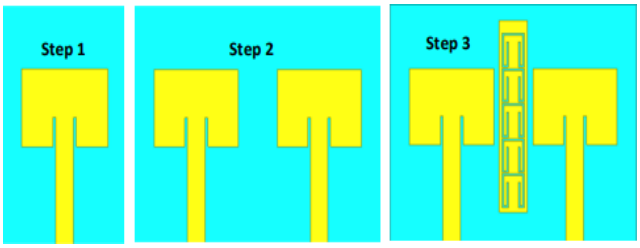

Fig. 1. Steps for designing of MIMO antenna

1. Fig. 1, illustrates the three-step iterative design procedure for the proposed MIMO antenna.
2. First, an effective single radiating element patch antenna with a microstrip feed is created and optimised.
3. The optimised antenna's width and length were determined to be 15 mm and 13 mm, respectively.
4. Second, a second patch antenna is created next to the previous one, as seen in step 2 of Figure 1.
5. The proposed metamaterial structure's unit cell, which is depicted in Figure 1, serves as the decoupling structure.
6. In figure 1 (step 3), the unit cells are employed between the antennas to create a strong isolation between the two antenna parts.

5. Proposed Model

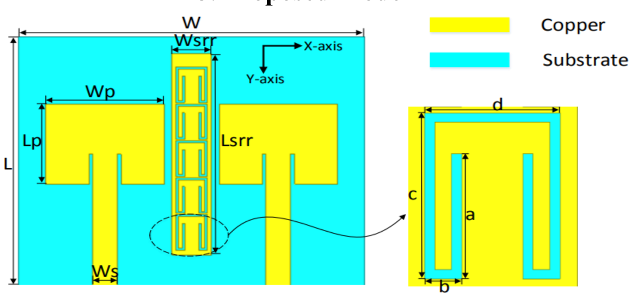

Fig. 2. Design of proposed antenna

The suggested antenna is printed on a cheap FR-4 substrate with a relative permittivity of 4.4 and a loss tangent of 0.02 correspondingly. With a 50 characteristic impedance and 3 mm larger microstrip lines, the proposed design stimulates two patches. Between radiating units, the MIMO antenna maintains an edge-to-edge separation of 7mm. First, a microstrip feed is used in a single radiating element patch antenna that has been built and optimized for performance. The optimal antenna was chosen to have dimensions of 15 mm in width and 13 mm in length. In addition, a second patch antenna is created next to the first. A decoupling structure is employed, which is the unit cell of the suggested metamaterial structure. A good isolation between the two antenna elements is achieved by using unit cells between the antennas. the loneliness Analysis of the surface current distribution of the antenna at the relevant frequency can also be used to explain behavior. In both scenarios (using metamaterial and not) the current distribution at 5.8 GHz is shown in. Due to the current being tightly linked to another radiator, the excitation of port 1 of a two port antenna results in a significant mutual coupling between the monopoles. The placement of metamaterial unit cells between the two radiating elements obviates the need for mutual coupling. Consequently, a very low mutual coupling is attained.

Table 1
Dimensions of proposed antenna

Parameter	Value (mm)
L	37
a	4
Wp	15
Lp	13
W	44
b	1.1
C	5.3
Wssr	5
Ws	3
Lssr	30
d	4

Software used:

High-performance 3D EM analysis software for designing is called CST Studio Suite®. examining and improving electromagnetic (EM) systems and parts. All of the modules use the CST Studio Suite design environment, which has a simple user interface. It includes a schematic layout tool, a pre-processor for the electromagnetic solvers, a 3D interactive modelling tool, and post-processing tools designed to meet industry needs.

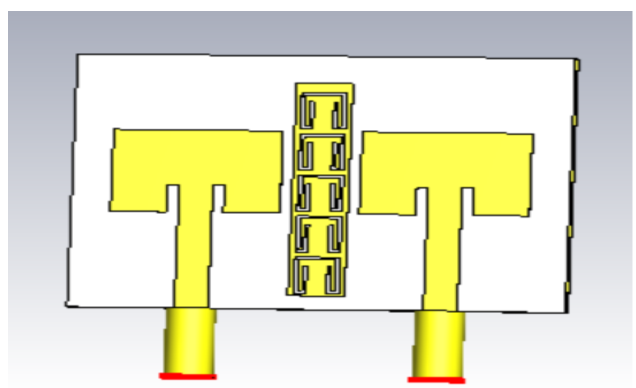

Fig. 3. 3D view of antenna

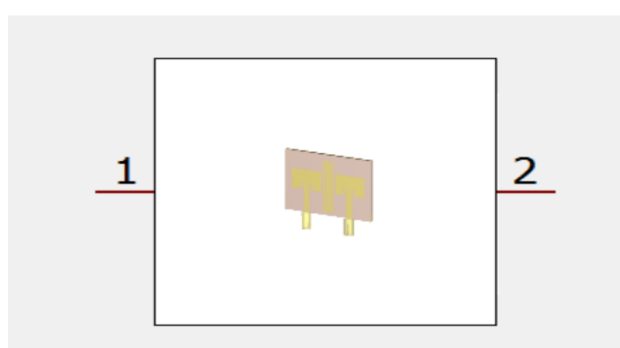

Fig. 4. Schematic view of wireless antenna

The 3D antenna created using the CST Studio Suite 2022 software is shown in figure 3. Here, a metamaterial decoupling structure separates two microstrip antennas.

6. Results

A. Testing

Here we have tested three different designs and compared the difference between them.

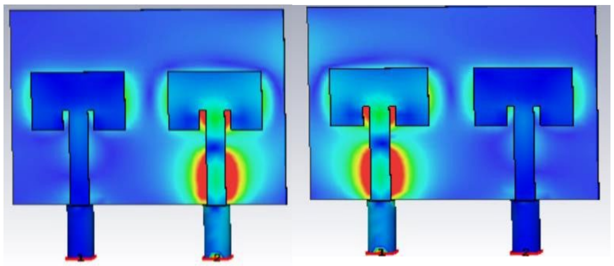

Fig. 5. Without parasitic material

Fig. 5 shows that if current is given for antenna 2, antenna 1 reflects some radiation and the same if antenna 1 then antenna 2 reflects some radiation.

B. Farfield Pattern

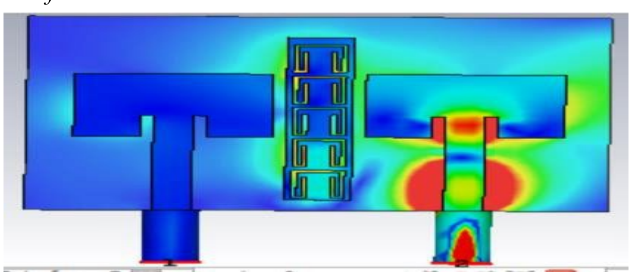

Fig. 6. Without parasitic material

Fig. 6 shows that if we place a parasitic material between two patch antennas, no radiation is reflected to another antenna when we supply power to one antenna.

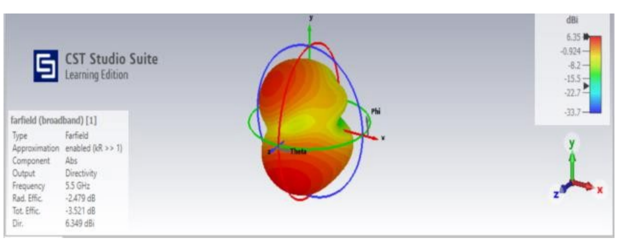

Fig. 7. Farfield diversity in 3D pattern

Fig. 7, shows the maximum directivity at 5.5 GHz in a metamaterial antenna is 6.349 dBi while the total efficiency is -3.521 dB. In Figure 7.2 blue line indicates Theta-axis, red line indicates X-axis, and green line indicates Phi-axis.

C. Realized Gain

Gain, which combines directivity and radiation efficiency, is a crucial indicator of an antenna's performance. The maximum gain in fig. 8, is 5.79 GHz frequency range is 4.287 dB.

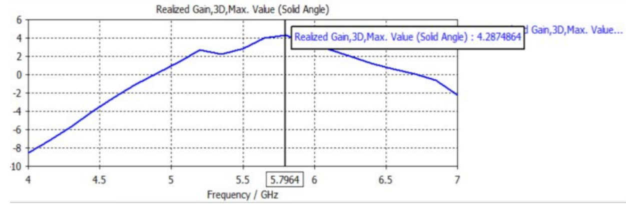

Fig. 8. Realized gain

D. Envelope Correlation Coefficient

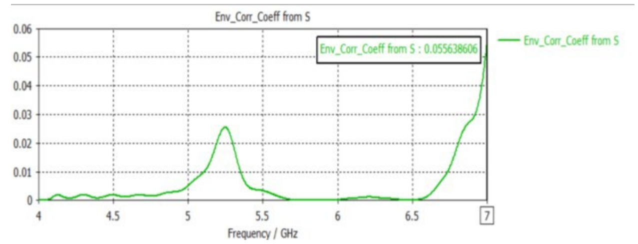

Fig. 8. Envelope coefficient correlation

Envelope correlation coefficient tell about how independent two antennas' radiation patterns are. Envelope Correlation Coefficient of 0.055 is obtained in fig. 8.

E. Voltage Standing Wave Ratio

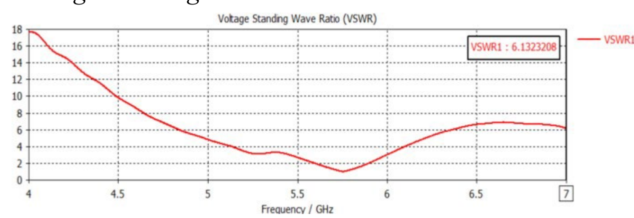

Fig. 9. Voltage standing wave ratio

Voltage standing wave ratio is a measure of how efficiently radio frequency power is transmitted from a power source, through a transmission line, into a load.

F. Diversity Gain

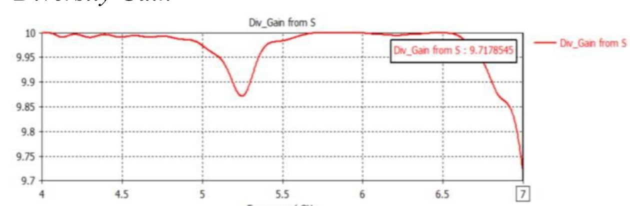

Fig. 10. Diversity gain

Diversity Gain, which is an increase in signal-to-interference ratio brought on by a diversity scheme, reached a maximum of 9.717 dB at frequency 7Ghz.

G. Surface Current

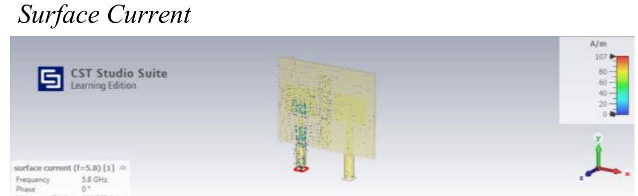

Fig. 11. Surface current

Surface current is an actual electric current that is induced by an applied electromagnetic field. Maximum surface current of 106.962 A/m is obtained at radiating frequency of 5.8GHz.

H. S Parameters

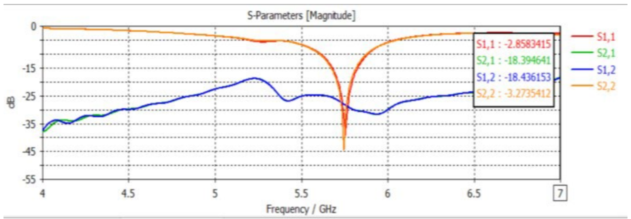

Fig. 12. S parameters

S-Parameters describes the input-output relationship between ports in antenna. From fig. 12 we obtained port S1, S2, S3 & S4 parameters.

I. Port Signal

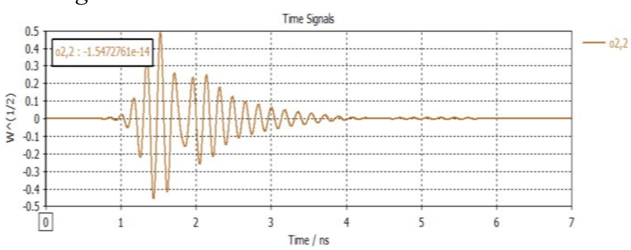

Fig. 13. Port signal

In fig. 13, the signal starts at zero and after some resonance the signal is tending towards zero which explains the antenna shows strong resonance.

7. Conclusion and Future scope

The design, development, and measurement of a MIMO antenna that is helpful for MIMO applications have been fully described throughout the scope of the project that has been provided. With a basic design and a dimension of 44 x 37 mm2, the suggested antenna operates at 5.1 GHz. The MIMO antenna's radiating patches can be separated from one another with a high degree of isolation thanks to the use of metamaterial structure. The proposed antenna has good characteristics, especially in terms of Envelop Correlation Coefficient (ECC 0.2) and Diversity gain (DG>9 dB), which qualify it as a suitable MIMO system option. Massive MIMO's large-scale active antenna arrays on 4G networks will enable widespread adoption of 5G technology, eradicating the wireless networks' bottleneck caused by scarce spectrum before 5G is introduced and enhancing the use of mobile Internet. A high-speed single-user experience is wrapped in a high-capacity system by the multi-user spatial multiplexing technique used in Massive MIMO. Astonishing user capacity can be delivered by this at very high, gigabit-level cell throughput, equivalent to an ultra-wide carrier. Similar bandwidth and QoS assurances to fixed networks are also provided by massive MIMO.

These factors indicate that it will proliferate in next-generation wireless cellular networks. With projections that more than 90% of the top 100 operators in the world will have started implementing it by the end of 2017, the massive MIMO industry has enormous potential. Operators now have a unique potential to offer a universal wireless broadband service thanks to the technology. Due to Massive MIMO wireless networks' limitless potential, the following operational and service breakthroughs are anticipated.

References

[1] Ludwig, A. Mutual coupling, gain and directivity of an array of two identical antennas. IEEE Trans. Antennas Propag. 1976, 24, 837–841.
[2] Iqbal, A.; Saraereh, O.A.; Ahmad, A.W.; Bashir, S. Mutual Coupling Reduction Using F-Shaped Stubs in UWB-MIMO Antenna. IEEE Access 2018, 6, 2755–2759.
[3] Su, S.W.; Lee, C.T.; Chang, F.S. Printed MIMO- antenna system using neutralization-line technique for wireless USB-dongle applications. IEEE Trans. Antennas Propag. 2012, 60, 456–463.
[4] Ghosh, J.; Ghosal, S.; Mitra, D.; Bhadra Chaudhuri, S.R. Mutual coupling reduction between closely placed microstrip patch antenna using meander line resonator. Prog. Electromagn. Res. 2016, 59, 115–122.
[5] Zhang, S.; Lau, B.K.; Sunesson, A.; He, S. Closely-packed UWB MIMO/diversity antenna with different patterns and polarizations for USB dongle applications. IEEE Trans. Antennas Propag. 2012, 60, 4372–4380.
[6] Suntives, A.; Abhari, R. Miniaturization and isolation improvement of a multiple-patch antenna system using electromagnetic bandgap structures. Microw. Opt. Technol. Lett. 2013, 55, 1609–1612.
[7] Yu, A.; Zhang, X. A novel method to improve the performance of microstrip antenna arrays using a dumbbell EBG structure. IEEE Antennas Wirel. Propag. Lett. 2003, 2, 170–172.
[8] Wu, W.; Yuan, B.; Wu, A. A Quad-Element UWB- MIMO Antenna with Band-Notch and Reduced Mutual Coupling Based on EBG Structures. Int. J. Antennas Propag. 2018, 2018, 8490740.
[9] Farsi, S.; Aliakbarian, H.; Schreurs, D.; Nauwelaers, B.; Vandenbosch, G.A. Mutual coupling reduction between planar antennas by using a simple microstrip U-section. IEEE Antennas Wirel. Propag. Lett. 2012, 11, 1501–1503.
[10] Zhu, F.G.; Xu, J.D.; Xu, Q. Reduction of mutual coupling between closely-packed antenna elements using defected ground structure. Electron. Lett. 2009, 45, 601–602.
[11] Chandel, R.; Gautam, A.K.; Rambabu, K. Design and Packaging of an Eye-Shaped Multiple- Input–Multiple-Output Antenna with High Isolation for Wireless UWB Applications. IEEE Trans. Compon. Packag. Manuf. Technol. 2018, 8, 635–642.
[12] Zhu, J.; Li, S.; Liao, S.; Xue, Q. Wideband Low- Profile Highly Isolated MIMO Antenna with Artificial Magnetic Conductor. IEEE Antennas Wirel. Propag. Lett. 2018, 17, 458–462.
[13] Liu, P.; Sun, D.; Wang, P.; Gao, P. Design of a Dual-Band MIMO Antenna with High Isolation for WLAN Applications. Prog. Electromag. Res. 2018, 74, 23–30.
[14] Sharawi, M.S. Printed MIMO Antenna Engineering; Artech House: Norwood, MA, USA, 2014.
[15] Choukiker, Y.K.; Sharma, S.K.; Behera, S.K. Hybrid fractal shape planar monopole antenna covering multiband wireless communications with MIMO implementation for handheld mobile devices. IEEE Trans. Antennas Propag. 2014, 62, 1483–1488.