REVA UNIVERSITY
Bengaluru, India
Established as per the section 2(f) of the UGC Act, 1956,
Approved by AICTE, New Delhi

School of Electronics and Communication Engineering

Sem: 7th & 8th	**Major Project Synopsis**	**Year: 2022-2023**

Project Group Members Details

Group No: G065 | **Group Name : FALCONS**

Sl. No	**SRN**	**Full Name**	**Section**	**Student Signature**
1	R19EC094	Harshitha U	B	
2	R19EC097	Jahnavi B	B	
3	R19EC110	Kavya V V	B	

Mini Project Details

Project Title:	Design of Compact MIMO Antenna for Ultra-Wide Band Applications	
Guide Details:	**Name: Dr Mrinal Sarvagya** **Designation: Professor**	**Mobile No: 7892708198**
Remarks by Guide:		**Guide Signature** **Date:** **Time:**

Project Title: Design of Compact MIMO Antenna for Ultra-Wide Band Applications

Abstract:

In this study an ultra-wideband MIMO antenna for various applications is presented. A compact multiple-input–multiple-output (MIMO) hexagonal antenna consisting of two open L-shaped slot (LS) antenna elements and a narrow hexagonal slot on the ground plane. The antenna elements are placed parallel to each other. Microstrip antenna is used because of compact size, conformal shape, easy and inexpensive to manufacture using printed-circuit technology. when the particular patch shape and mode are selected, Multiple-input multiple-output (MIMO) antenna technology can significantly improve data transmission speed and channel capacity, when MIMO antenna is used in UWB application then it increases the high data transmission range.

Keywords: MIMO, Microstrip, UWB, high data transmission, mutual coupling

Description of the proposal:

- Multiple-Input Multiple-Output (MIMO) technology uses several transmitters and receivers together to exchange more data at the same time.
- MIMO enable the antennas to add signals coming from different paths and at different instants to increase receiver signal capturing capacity effectively.
- The use of several antennas enables MIMO wireless technology to noticeably increase the capacity of the given channel.
- The Proposed antenna consists of a dual hexagonal patch with L-shaped slot tapered from a microstrip feeding for each antenna element structure and has a truncated ground plane with hexagonal slot.

- The proposed antenna is etched onto a FR4 substrate, with an overall size of 36 mm × 40mm × 1.6mm.

- Simulated results are shown to be in good agreement. Experimental results indicate that the antenna achieved an UWB bandwidth which ranges from 3.1GHz -10.6 GHz. These characteristics make the designed antenna suitable for various UWB applications

Objectives of the project:

MIMO antenna system has capability to improve the overall antennas performance but in addition to these advantages subject there are new challenges also such as, reducing the mutual coupling and the correlation between the elements.

In modern wireless communication system, high data rate and channel bandwidth must be at highest priority. In the field of MIMO antennas the main area of work for researchers is to improve channel capacity, bandwidth, gain, and polarization diversity while reduce coupling between antenna elements.

Literature Survey

In the metallic printed structure due to the use of multiple antennae the performance is affected by the mutual coupling of the antenna. To reduce the coupling, a cylindrical dielectric resonator antenna (CDRA) is introduced in the paper. In this paper, the main focus is on the multiple frequency advancement of the CDRA by two different micro strip feed lines. Two methods for achieving multi band in a cylindrical resonator antenna are investigated. The first is to cut a slot in a radiating element, and the second is to partially ground it [1].

In [2], a neutralization line is added between two radiation elements, and it connects to the elements. The neutralization line contains two metal strips connected via rhombus plate. The line effectively reduces the coupling current at ground and achieves a wideband decoupling current. A high isolation is achieved by exploiting the polarization of the multiple elements.

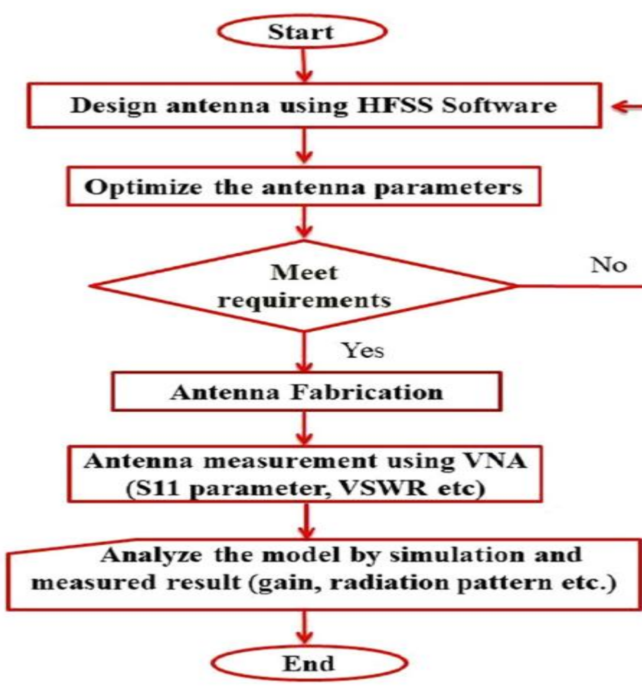
This study presents an 8-element MIMO antenna based on 5G connectivity. Two spit ring resonators with a C-shaped arrangement make up the antenna. Four liner slots are presented in groups and engraved between the centres of two elements to enhance separation. To boost group separation, four linear slots are proposed and engraved between the centres of 2 elements, isolation is more than 14 dB which meets the requirements for a mobile communication application [3].

In [4], a four-element MIMO antenna with polarization diversity technology has a high isolation and a small size. However, the substrate of this antenna is Rogers TMM4. The material is very expensive. The size of the four-element MIMO antenna mentioned in [10] is small, but the isolation is not good, only less than −16 dB. The line effectively reduces the coupling current at ground and achieves a wideband decoupling current. A high isolation is achieved by exploiting the polarization of the multiple elements.

Methodology of the project:

The work flow followed in the design process of the antenna:

- Designing of antenna using HFSS software according to the requirement.
- Optimize the antenna parameters such as S11 parameter, gain, bandwidth and radiation pattern.
- Once after the requirements are met then the antenna is fabricated.



Diagrams/Designs/Flow charts:

Components used:

1. FR4 Substrate:

FR4-Flame Retardant 4 (FR4) substrate of dielectric constant, ε_r =4.4 sandwiched between copper patch and ground plane. The designed antenna has compact area and operating bandwidth of 560 MHz (7.67 GHz-8.22 GHz). It is the most common grade dielectric material that is used in the fabrication of circuit boards. This material is incorporated in single-sided, double-sided, and multi-layered boards. Here are a few qualities of FR4 materials:

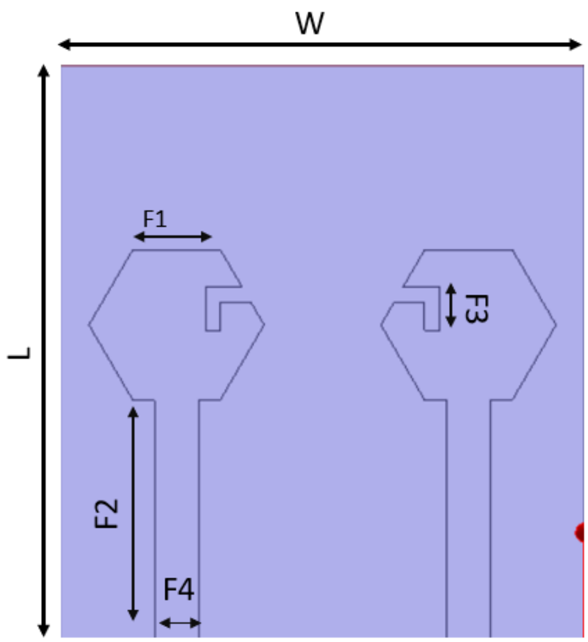
- Wide range of operating temperature (50°C to 115°C)
- Offers decent mechanical properties to maintain board structure integrity
- Cost friendly when compared to other materials
- This material performs as an insulator
- Good electrical properties
- Low moisture absorption

2. Feed port-sma connector

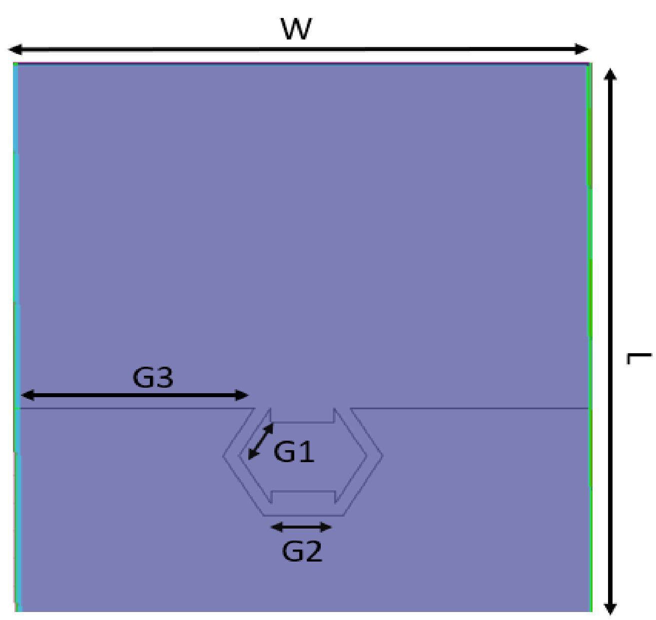
It is Sub Miniature Version A(SMA). It is a coaxial connector and the standard for antenna connections. In order to maintain the transmission speed of coaxial cables, both versions of the corresponding connectors have a coaxial design. They therefore have good electrical shielding and low electromagnetic interference. They are now used in many different devices and applications in the high-frequency range.

DESIGN :

Front design of antenna :



Design of Ground plane:

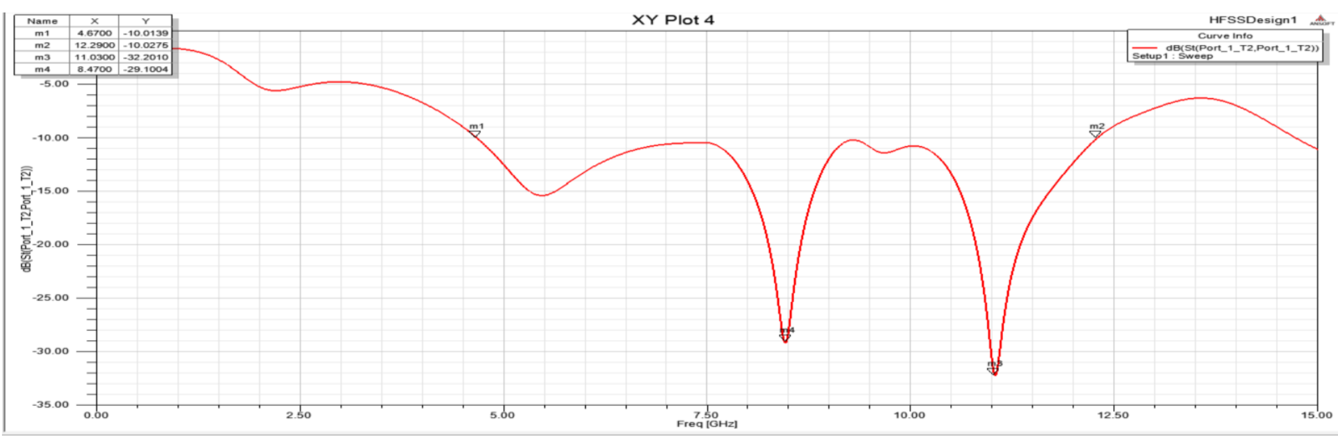


Dimension of proposed antenna:

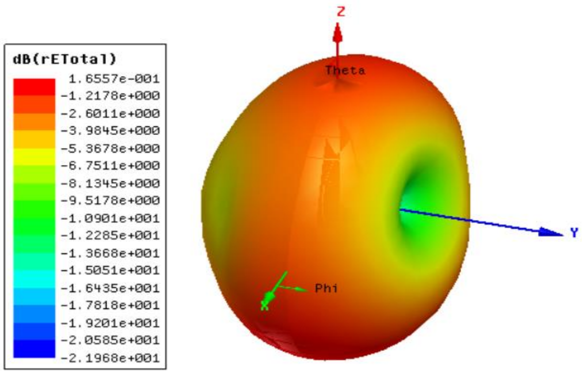
Basic configuration	Variable	Dimension
Substrate	W L T	36 mm 40 mm 1.6 mm
Patch Antenna	F1 F2 F3 F4	6.0 mm 16.6 mm 3 mm 3.4 mm
Ground plane	G1 G2 G3	4 mm 5 mm 15 mm

Expected output of the project:

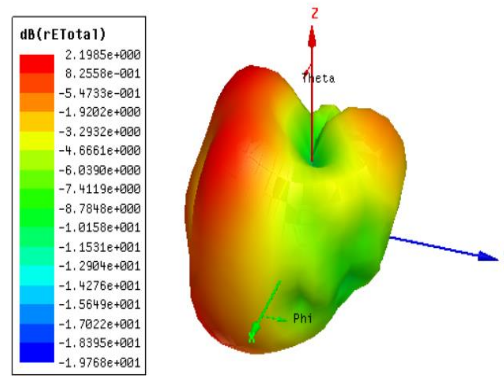
S11 Parameter: The simulated S11 result of the proposed structure is depicted in the figure. The antenna shows good S11<-10dB. (Range – 4.67GHz to 12.29GHz)



Gain: Antenna gain is a measure of its ability to direct or concentrate radiated power in a particular direction compared to an isotropic radiator. The simulated and measured gain of the proposed MIMO UWB antenna are illustrated in below Figure.

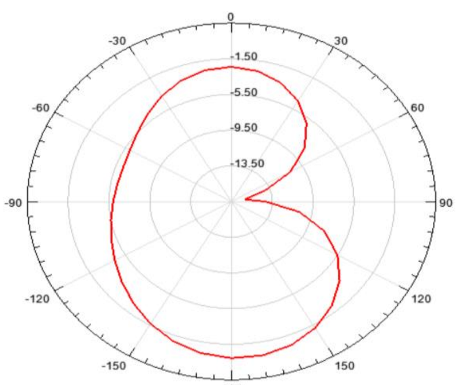


Gain for 4.67GHz

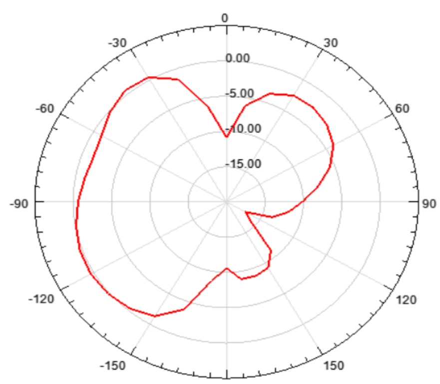


Gain for 12.29GHz

Radiation Pattern: The radiation pattern describes how the antenna radiates electromagnetic energy in different directions. It represents the spatial distribution of radiated power as a function of direction. Constraints can be defined to ensure that the antenna's radiation pattern meets the desired specifications, such as beamwidth, directivity, sidelobe levels, and polarization characteristics.



Radiation Pattern for 4.67 GHz



Radiation Pattern for 12.29 GHz

Conclusion and Future Scope

A Compact two port ultra-Wide Band antenna with the overall Dimensions of 40mm x 36mm x 1.6mm for wireless communication applications has been proposed. Simulated and measured results have shown that the antenna can operate in the ultra-Wide Band from 4.67–12.29GHz with a high isolation (−17 dB). Polarization diversity, protruded ground, and parasitic elements are used in the MIMO antenna to achieve the higher isolation. The measured return loss, isolation, and radiation pattern agree with the simulated ones. The use of antennas has been studied. Over all these results will indicate that the ultra-Wide Band antenna is potential for portable wireless communication applications. This antenna can be a good candidate for ultra-Wide Band wireless communication applications which are going to proliferate in a wide variety of ways in all wireless scenarios. In this work, we reviewed various fractal geometry antennas used for multiband and Wide Band wireless applications and a comparative analysis of various characteristics are discussed. Improvement of various characteristics can be achieved using different feeding method, DGS on the ground, position of feeding method, and by changing the width and length of the slot. Also, the effect of this on bandwidth, gain, and return loss is discussed where it is observed that multiband characteristic with improvement in bandwidth and return loss can be achieved using fractal geometry. As a result, fractal geometry antennas can be used for many wireless applications such as radar, satellite communication, military, GPS, GSM, 3G, LTE, WI-Max, Point-to-Point communication and in future for 5G technology. It is evident from the present study that it is possible with enhancement through the proposed compact fractal meta material antenna. The broad impedance bandwidth and relatively small antenna size are attributed to the introduction of meta material as a ground plane. This proposed antenna is suitable for the frequency range of 4.67–12.29GHz. The proposed design approach provides a miniature size and returns loss performance of the proposed fractal antenna with moderate gain over the entire band and makes it suitable for wireless and Wide Band applications. In summary, the proposed antenna is a promising candidate for UWB-MIMO wireless applications.

REFERENCES

[1] Ahmad, S.; Khan, S.; Manzoor, B.; Soruri, M.; Alibakhshikenari, M.; Dalarsson, M.; Falcone, F. A Compact CPW-Fed Ultra-Wideband Multi-Input-Multi-Output (MIMO) Antenna for Wireless Communication Networks. IEEE Access 2022, 10, 25278–25289.

[2] Chen, Z.; Zhou, W.; Hong, J. A Miniaturized MIMO Antenna with Triple Band-Notched Characteristics for UWB Applications. IEEE Access 2021, 9, 63646–63655.

[3] C. R. Jetti and V. R. Nandanavanam, “A very compact MIMO antenna withtriple band-notch function for portableUWB systems,” Prog. Electromagn.Res.C,vol. 82,no. March,pp. 13– 27,2018,doi:10.2528/pierc18011201.

[4] S. Punith, S. K. Praveenkumar, A. A. Jugale, and M. R. Ahmed, “ANovelMultibandMicrostripPatchAntennafor5GCommunications, ”ProcediaComput. Sci., vol. 171, no. 2019, pp. 2080–2086, 2020, doi:10.1016/j.procs.2020.04.224.

[5] T. Addepalli and V. R. Anitha, “Design and parametric analysis of hexagonal shaped MIMO patch antenna for S- Band, WLAN, UWB and X-band applications,” Prog. Electromagn. Res. C, vol. 97,no. November, pp. 227–240, 2019, doi: 10.2528/PIERC19101004.

[6] S. Chouhan, D. K. Panda, V. S. Kushwah, and S. Singhal, “Spider-shapedfractalMIMO antennaforWLAN/WiMAX/Wi Fi/Bluetooth/C-bandapplications,” AEU - Int. J. Electron. Commun., vol. 110, p. 152871,2019, doi:10.1016/j.aeue.2019.152871.

[7] A. Ahmad and F. A. Tahir, “Multiband Reconfigurable MIMO Antenna for GSM/GPS/GLONASS/LTE/WWAN Wireless Terminals,” 2020 Int. Conf. UK- China Emerg. Technol. UCET 2020, pp. 36–41, 2020, doi: 10.1109/UCET51115.2020.9205471.

[8] M. Klemm, I. J. Craddock, J. A. Leendertz, A. Preece, and R. Benjamin, “Radar-based breast cancer detection using a hemi spherical antenna array - Experimental results,” IEEE Transactions on Antennas and Propagation, vol. 57, no. 6, pp. 1692– 1704, 2013.

[9] Ayman A. Isaac and Hussain M. Al-Rizzo, “Coupling reduction of two planar monopole antennas for modern wireless applications,” 2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, pp. 420-421, 2020.

[10] Stefano Pisa, Erika Pittella and Emanuele Piuzzi, “A survey of radar systems for medical applications,” IEEE Aerospace and Electronic Systems Magazine, pp. 64-81, Dec. 2019

[11] Lazaro, R. Villarino, and D. Girbau, “Design of tapered slot Vivaldi antenna for UWB,” Microwave and Optical Technology Letters, vol. 53, no. 3, pp. 639–643, 2017. Design of Compact MIMO Antenna for Ultra-Wide Band Applications School of ECE, REVA University, Bengaluru. 25

[12] Stefano Pisa, Erika Pittella and Emanuele Piuzzi, “A survey of radar systems for medical applications,” IEEE Aerospace and Electronic Systems Magazine, pp. 64-81, Dec. 2019

[13] K. Manuel Prasanna and S. K. Behera, "Compact two-port Ultra wideband MIMO antenna system with high isolation using a fork-shaped structure," 2013 International Conference on Communication and Signal Year, pp. 726-729, 2022.

[14] M. Sharma, V. Dhasarathan, S. K. Patel, and T. K. Nguyen, "An ultra-compact four-port 4×4 super wide band MIMO antenna including mitigation of dual notched bands characteristics designed for wireless network applications," AEU - Int. J. Electron. Commun., vol. 123, p. 153332, 2020, doi:10.1016/j.aeue.2020.153332

[15] P. Tamil Manoj Prasanth and G. Velmathi, "Design and development of cylindrical dielectric resonator (CDR)MIMO antenna for multiband applications," Proc. 2016 IEEE Int. Conf. Wirel. Commun. Signal Process. Networking, WiSPNET 2016, pp. 670–673, 2016, doi: 10.1109/WiSPNET.2016.7566217.

Name and Signature of Guide:

Dr Mrinal Sarvagya

Team Member and Signature:

Harshitha U

Jahnavi B

Kavya V V