DESIGNING OF MIMO ANTENNA FOR SIGNAL BOOSTER DEVICE TO ENHANCE THE SIGNAL CONNECTIVITY IN RURAL AREAS

Project Reference No.: *47S_BE_3428*

College ***:*** *Nagarjuna College of Engineering and Technology, Bangalore*
Branch ***:*** *Department of Electronics and Communication Engineering*
Guide(s) ***:*** *Dr. Vivek Singh*
Student(S) ***:*** *Mr. Naseer Ulla Khan*
Mr. Rahul Yadav
Ms. Priyanka R
Ms. Gowthami L.R.

Keywords:

Millimeter wave, MIMO Antenna, Gain, Impedance Bandwidth, Polarization

Introduction:

If you reside in a remote region, you are almost certainly miles from a cell tower. Cell signal strength is greatest at the source (the cell tower) and diminishes as it goes, resulting in the poor signal. In isolated places, buildings are often surrounded by woods, mountains, or hills, or a mix of the three. These geographical characteristics interfere with or degrade the signal strength of mobile phones. The signal loses power as it passes past such obstructions on its way to your phone's antenna. If you struggle to maintain a strong, consistent mobile signal, a cell phone signal booster can undoubtedly assist you. A cellular booster is a device that utilises an external antenna to collect an existing outside signal, an amplifier to boost the signal, and an interior antenna to rebroadcast the increased signal. In remote areas, it is critical to have a dependable mobile phone service. A home booster will assist in alleviating the annoyance associated with an unreliable mobile phone signal. The whole globe is reacting to the reality of the Covid-19 epidemic by devising workarounds for the disturbances already experienced. Corporations are enabling employees to work from home, while schools and institutions are transitioning to online classrooms. In India, individuals are largely reliant on good internet connections, laptops, and cell phones to resume normalcy. Students have been prompted to pursue e-learning alternatives by the crisis, which has no end in sight. As the nation transitions to online education, the present epidemic is disproportionately affecting rural students. However, even in isolated rural locations, e-learning is revolutionizing the industry. Tier-3 and Tier-4 municipalities are stepping up their game by investing in the development of digital education systems. While many are taking advantage of online education, local governments are having difficulty integrating high-speed internet facilities. Additionally, rural residents must contend with irregular power supplies and outdated technological gadgets, which often obstruct smooth access. Thus, multiple-input multiple-output (MIMO) may be used to augment signal coverage in rural locations while still offering high-speed broadband connectivity.

With the introduction of 5G wireless communications, multiple input multiple output systems are anticipated to play a major role owing to advantages of high date rate, quality, reliability and channel capacity in scattering environment without the need for additional transmitter power. However the mutual coupling induced between the MIMO elements acts as major disadvantage.

Objectives:

1. Modelling, Simulation, Fabrication and Measurement of Planar/Dielectric Resonator Based Antennas on high frequency laminate.
2. Designing the antenna with the assistantship of simulation software HFSS and achieve the desired specifications.
3. Perform the parametric analysis and formulating the mathematical behaviour for the proposed module.
4. Introduction of the additional components to enhance high gain and wide operating bandwidth.
5. Design the Multiple-Input-Multiple-Output (MIMO) antennas from the single antenna under the investigation for 5G Applications.
6. To obtain better isolation among multiple input multiple output antenna elements and high radiation efficiency.
6. Fabrication of Antenna and verified the outcomes experimentally.
8. Publish the findings in the journals of reputes (SCI/Scopus) and go for the patent filing of the proposed configuration and possible inclusion for commercialization.

Methodology:

Choice of antenna and its design:

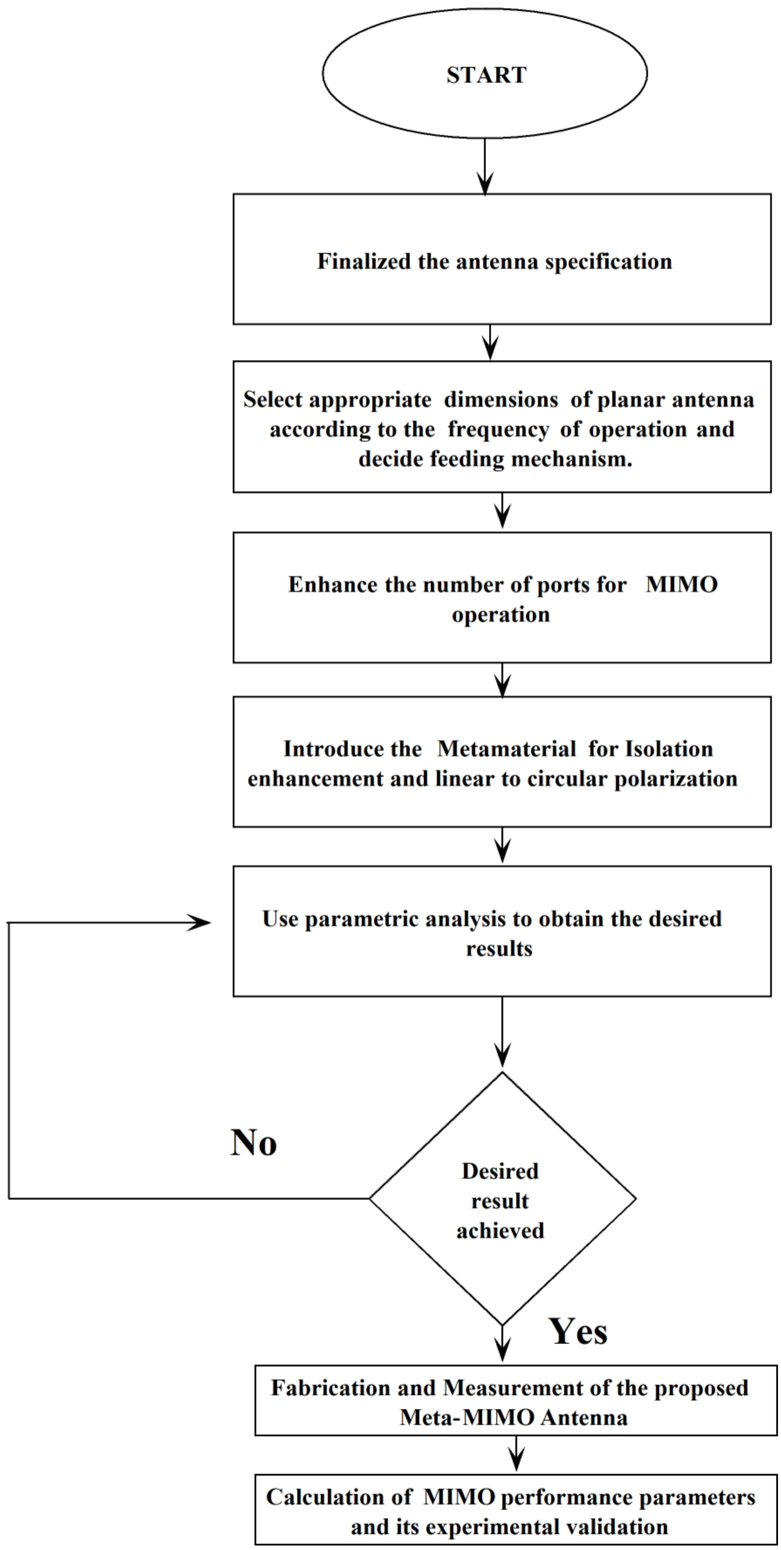
Design specification of a micro-strip antenna and dielectric resonator based antenna is an important factor which determines the performance of the antenna. However, before the actual prototyping and experimental testing it is necessary to validate the patch antenna performance. Antenna designs can be simulated by means of commercially available HFSS software and other similar tools. The result is readily available for analysis and for experimental investigations.

Prototyping of the antenna design:

Antenna prototyping is an important stage of antenna design. The off the shelf substrates or especially designed substrates for antenna fabrication can be used for patch designing through a milling/drilling PCB machine or can be made through chemical process of etching the conductor out of PCB.

Testing of the antenna prototypes:

The simulated and fabricated antenna design requires experimental verification. To experimentally test an antenna, a typical measurement system using a Vector Network Analyzer (VNA) and a stationary calibrated horn with the basic AMS (antenna measurement system) will be used.



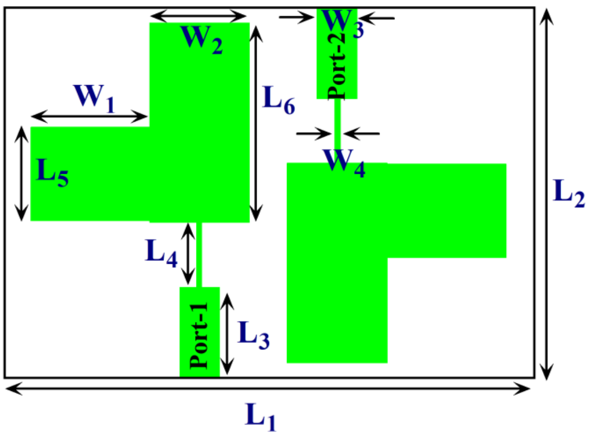
Flow chart For MIMO-Metasurface Design.

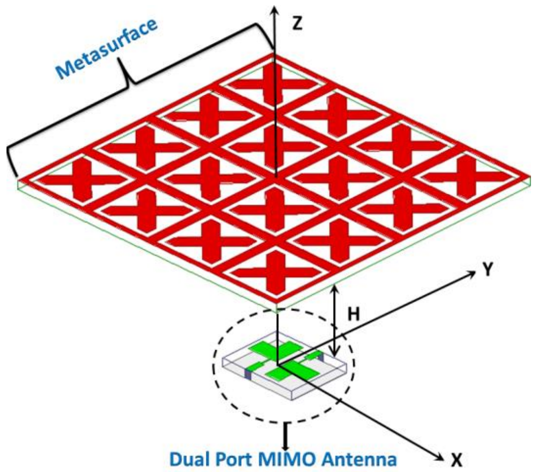
Results:

This comprehensive section is rganized into the following sections: (i) Designing and creating a prototype of an antenna with a specific geometry; (ii) Conducting analysis and investigation on the antenna; (iii) Developing a metasurface design (iv) Presenting and discussing the results of the study.

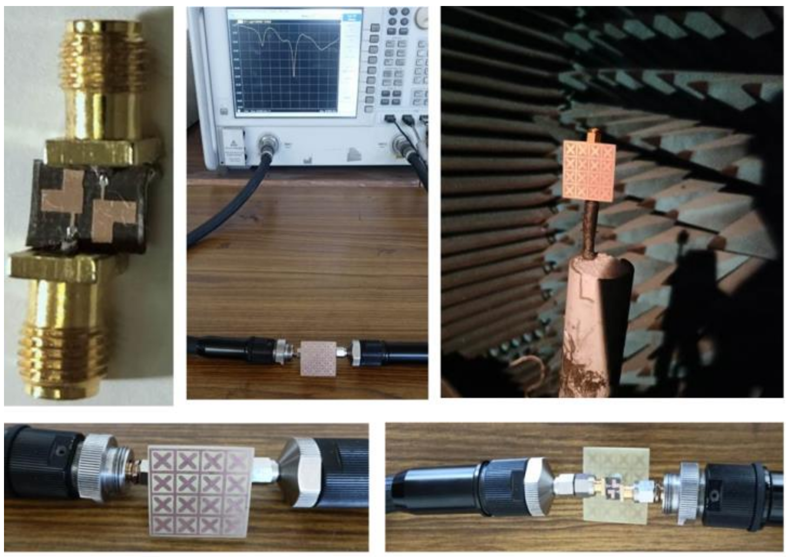
5. ***ANTENNA CONFIGURATION AND DESIGN***

Figure 1a & 1b depicts the structural arrangement, whereas figure 1c displays the fabricated prototype of the suggested model. The proposed model comprises a metasurface suspended stepped feed line excited dual port planar MIMO antenna, in which printed MIMO antenna is fabricated on a duroid 5880 substrate (εr of 2.2, tanδ of 0.0009), and metasurface is fabricated on a FR4 epoxy substrate (εr of 4.4, tanδ of 0.02) both of thickness of 0.8 mm.





(5) (b)



©

Figure 1 Proposed Model Geometrical Layout, (a) Dual Port MIMO Antenna (b) Metasurface Enabled MIMO Antenna, (c) Fabricated Antenna under Measurement Setup.

B. SINGLE ANTENNA UNIT

This section explores and examines the various stages of evolution for the recommended single antenna component. In order to reach the final version of the proposed antenna, four distinct steps (step-1 to step-4) are outlined. During this process, we will conduct a comparative investigation based on the |S11| (dB) values (c.f. figure 2).

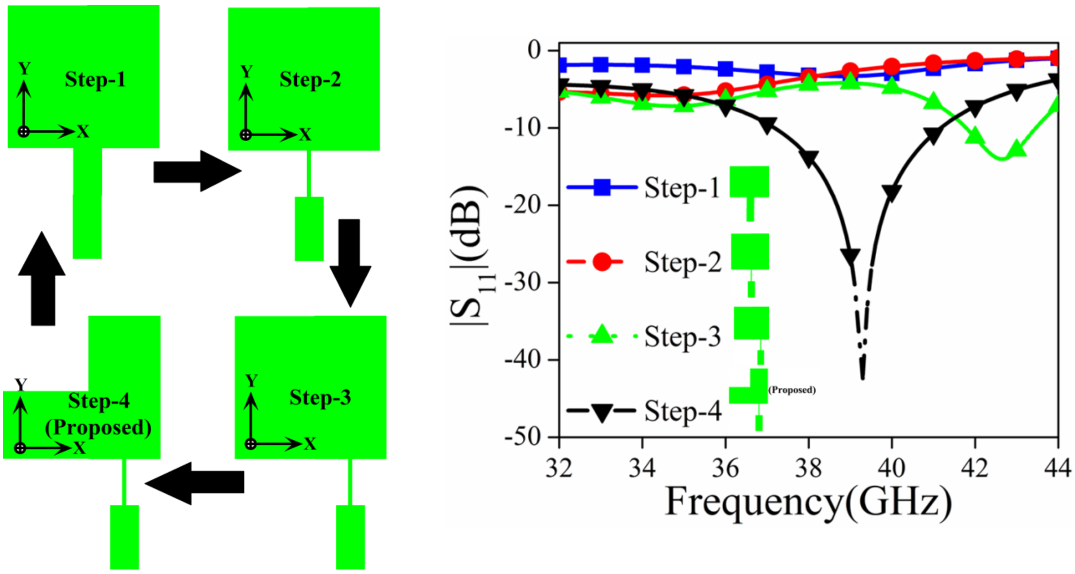


Figure 2 (a) The evolution steps of single antenna, (b) |S11| (dB) plot of the different evolution stages.

B. MIMO ANTENNA

The proposed 2-port MIMO design is created by duplicating the single antenna component in an anti-parallel back mirror arrangement. Figure 3 and figure 4 presents a comparative examination of several MIMO antennas by duplicating the same antenna element in multiple orientations and examining their return loss and isolation respectively. According to figure 4, four different MIMO antenna orientations are investigated in which OR-1 correspond to the parallel positioning of the antenna elements, OR-2 correspond to the back to back mirror positioning, OR-3 represent the orthogonal placement of the antenna units and OR-4 is obtained by placing the antenna elements in anti-parallel back mirror fashion. From the perusal of figure 3(a) it is observed that for OR-1 and OR-3, the variation of |S11| and |S22| are not same and while for OR-2 and OR-4 the |S11| and |S22| variation are same.

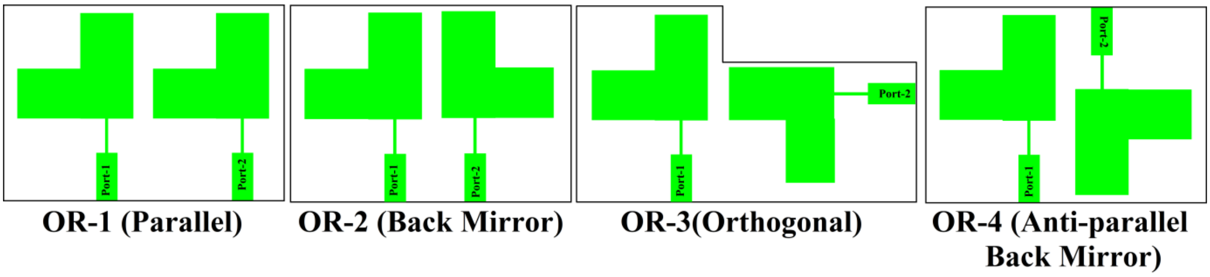


Figure 3. Different MIMO antenna orientation (OR-1, OR-2, OR-3 and OR-4).

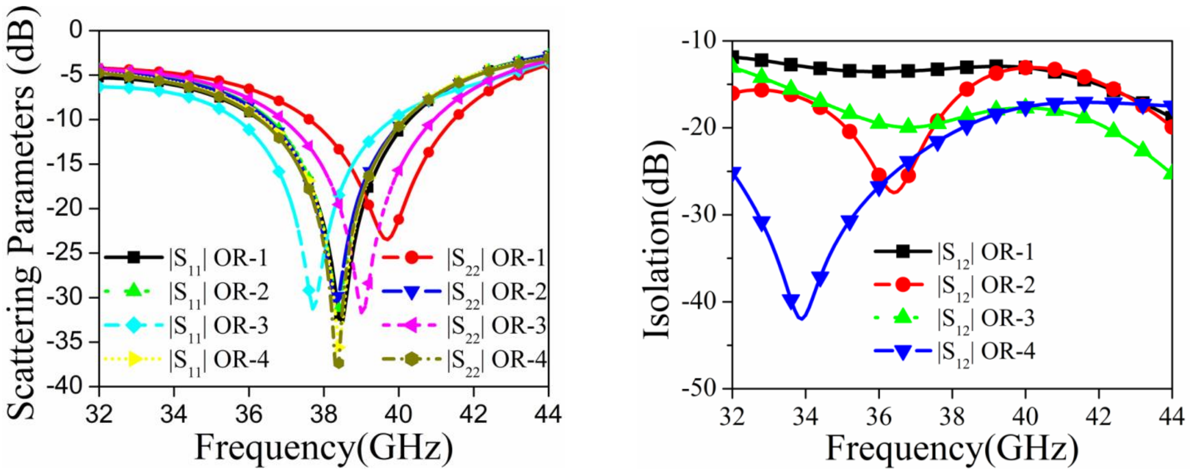


Figure 4 (a) Scattering parameters (|S11| and |S22|) and (b) Isolation (|S12|) of the different MIMO antenna orientation.

C. MIMO ANTENNA WITH METASURFACE

METASURFACE UNIT CELL DESIGNING

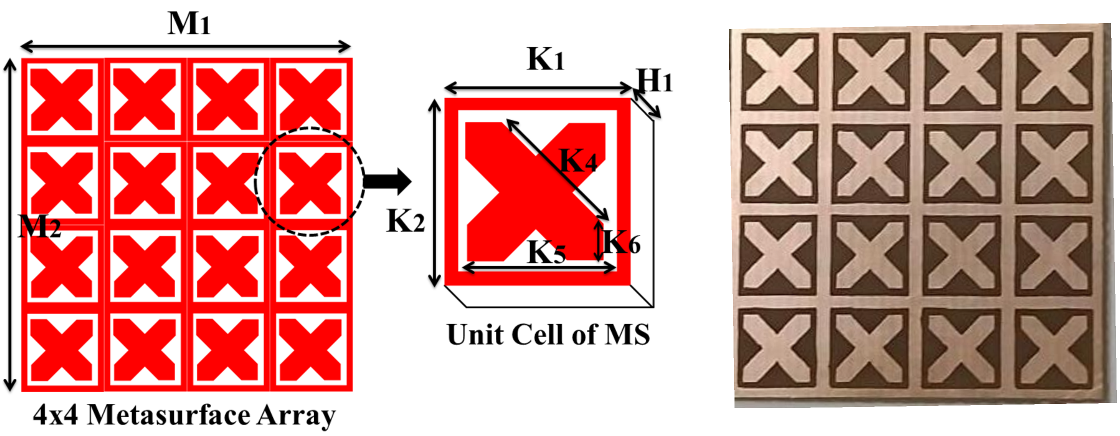


Figure 5. The geometrical specification of the proposed metasurface (a) Metasurface array and Unit Cell, (b) Fabricated prototype.

Conclusion:

This work proposes to design MIMO antenna system with minimal mutual coupling and more significant gain for signal booster device. The simulated results of the fabricated prototype are verified by measurement through vector network analyzer in anechoic chamber. The comparative analysis is also carried out between the proposed configurations and previously reported modules. In the proposed work a metasurface based planar antenna is modelled, analysed and investigated. Here a thin two-dimensional metasurface layer is utilized in the design of antenna. The integration of metasurface layer in the design and simulation of multiple input and multiple output antennas will improve the isolation among multiple antenna elements by suppressing the surface waves. Metasurface layers allow manipulation of electromagnetic waves which helps in enhancing the gain and bandwidth and to achieve circular polarization of the antenna system.

V. INNOVATION IN THE PROJECT

This study examines a compact MIMO antenna with metasurface loading, designed for 5G mm-wave applications for n260 band. The detailed investigation of the different orientation of the MIMO is presented with findings. The suggested metasurface model is behaved like a polarization converter converting the linearly polarized wave into circularly polarized wave as well as gain enhancer. The technical elements and physics behind these discoveries are also included. The diversity parameters, including ECC, DG, MEGs, and CCL are calculated to provide evidence for the MIMO characteristics of the proposed model. The integration of a metasurface into an mm-wave frequency antenna to provide LP to CP conversion with gain enhancement makes the suggested model innovative for n260 band 5G applications

Scope for future work:

The need for wireless communication has shown a significant and rapid increase in recent years. By the year 2030, it is projected that there will be around 17 billion mobile-connected devices, generating a monthly data flow of thousands of exabytes. Despite the much advancement in the Fifth Generation (5G) communications systems compared to Fourth Generation (4G) systems, they will be unable to meet the increasing demand and the needs of creative use cases. Consequently, Sixth Generation (6G) Networks are anticipated to provide extensive connection and ensure enhanced performance and quality of service for all customers. In order to handle such demands, several technological challenges must be resolved, such as the use of innovative multiple-antenna technologies. This assessment provides a succinct overview of the primary upcoming Multiple-Input Multiple-Output (MIMO) technologies for 6G Networks, including massive MIMO (mMIMO), exceptionally large MIMO (XL-MIMO), Intelligent Reflecting Surfaces (IRS), and Cell-Free mMIMO (CF-mMIMO). In addition, we provide a detailed analysis of how certain key performance indicators (KPIs) for various innovative 6G Network applications may be achieved via the advancement of each Multiple-Input Multiple-Output (MIMO) technology.