To Design & Develop MIMO Antenna Using Defected Ground Structure (DGS) Method

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Abstract

A compact hexagonal shape element Multiple Input Multiple Output (MIMO) technology has become very popular in a wireless communication system (i.e.) antenna bearing a high gain for 5G communication operating in the millimeter-wave spectrum is proposed. The high gain of the proposed antenna further helps to overcome the atmospheric attenuations faced by the higher frequencies. RIS and AMCs are widely used to improve the performance of antennas. An attempt is made to increase gain of the antenna by using Artificial Magnetic Conductor (AMC) and RIS. The AMC layer have a lower resonating frequency as compared to microstrip patch antenna. The AMC layers forms a cavity of height <0.1. The proposed antenna consists of sets of elements, and it is yielded at the central frequency of 5-6 GHz. The disadvantages of RF Modules is the cost of that systems. In this paper, the antenna selection techniques based on required direction is proposed. To get high gain and low mutual coupling for antenna, a Artificial Magnetic Conductor (AMC) is proposed and integrated on ground plane. The Suggested antenna model with is fabricated to verify the simulation results in terms of S-parameters, radiation patterns, gain, and diversity parameters. It is worth noting that the experimental results have the same trend of the simulation ones which makes the MIMO antenna applicable for high gain. MIMO Antenna can also be modified to provide circular polarization however, it suffers from low gain. narrow bandwidth. low efficiency, and low power handling capability. The experimental results validate the simulation design process conducted with HFSS Software.

Keywords: MSA, Single Band, Gain and Radiation Pattern

1.Introduction

With the advancement in technology, future wireless communications services demand high data rates. The development of multiple-input multiple-output (MIMO) technology is seen as a prerequisite for present and foreseeable wireless communication systems. The performance of wireless communication systems is considerably improved by MIMO technology, including the data rate, transmission speed, and channel capacity.. MIMO technology requires multiple antenna systems. The MIMO system is very compact antenna for portable MIMO devices . Multiple Input Multiple Output (MIMO) plays an important role in wireless communication systems. Different types of antennas are designed to meet the requirement of high gain MIMO antennas. Recently, researchers have focused their attention on the design of multifunctional antennas which have enormous characteristics in single structures for different types of applications. MSA are designed on RIS backed substrate to miniaturize the size of antenna and increase the gain of antenna. MSA sandwiched between RIS and AMC layer are designed to enhance the gain and bandwidth of antenna. High gain wideband antenna can be designed using RIS and AMC surface. Most nations are now standardizing 5G to meet the demand for higher bandwidth and data rates, which is in and of itself a difficult task.. To solve this problem, the Multiple Input Multiple Output (MIMO) technologies with a wide bandwidth characteristic are crucial to improve its gain and bandwidth. The higher mutual coupling between the MIMO antenna elements would affect the throughput of the MIMO antenna system .Thus, to design a MIMO antenna system with a high element isolation is also a challenge. The AMC and RIS method have been targeted by the 5G technology, which can further help to achieve the higher gain with a data rate up to several Gigabit-per-second (Gbps).

1.1 Aim and Objectives of Work

One of the main aims of MIMO antenna design is to increase the capacity and data rates of wireless communication systems. By utilizing multiple antenna elements at both the transmitter and receiver sides, MIMO antennas can spatially multiplex multiple data streams, allowing for higher data rates and increased capacity in wireless communication systems. MIMO antennas can mitigate the effects of fading, interference, and other propagation impairments by exploiting the spatial diversity of multiple antenna elements. Therefore, improving link reliability and reducing the impact of channel impairments is often an objective in the design of MIMO antennas. For 5G base station antenna in the restricted space efficiently for space utilization and cost reduction, the low profile antennas are more preferable.. Microstrip antenna is a good candidate for 5G base station antenna designs due to its attractive features of low profile, light weight, easy fabrication, and conformability to mounting hosts. To meet the requirements of 5G wireless communication system, in this research low profile MSA is designed on FR4 substrate. RIS layer is used to enhance the bandwidth, efficiency and to miniaturize the size of antenna. A superstrate FR4 layer is placed at a distance & it ; 0.1 λ0 above the MSA. On it, a parasitic patch is created, and its measurements are tuned. The impedance bandwidth and gain of the antenna will be improved by electromagnetic coupling between the two patches. On the other side of the superstructure, the AMC layer is constructed so that the waves coming from the area between the patches are in phase throughout a wide bandwidth, increasing the antenna's gain. To design and develop a MIMO antenna with a rectangular microstrip patch antenna with slits to achieve high gain for a 5G application and improve its performance using reactive impedance surface (RIS) and artificial magnetic conductor (AMC) layers that can provide (a) Gain of approximately 10-12 dBi (b) more than 70% antenna efficiency (c) less than -15 dB side lobe level (d) less than -15 dB cross polarisation(e) approximately 20dB front to back lob.

2. Design Of Microstrip Patch Antenna

The most common and widely used antenna type is the microstrip antenna (MSA), which has a number of appealing features, including light weight, small size, low profile, ease of fabrication, simplicity in integrating with microwave integrated circuits (MMICs), and a planarstructure that can be made conformal to host surface. But the MSA has poor directivity, a constrained bandwidth, limited efficiency, and weak power handling capacity. Utilizing a lowpermittivity, thick substrate, multi-resonator stack design can boost bandwidth. Furthermore, the reflectivity of the PRS affects the gain and bandwidth equally..As shown in Fig.3.1 Structure of microstrip patch antenna.

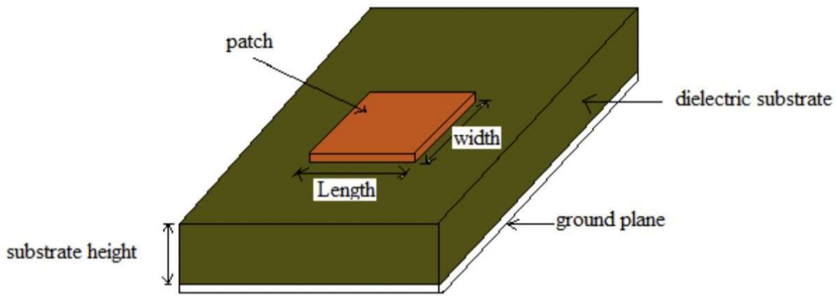


Fig. 2 Structure of microstrip patch antenna

High reflectivity PRS is used in order to obtain high gain, and an array of parasitic patches is placed on the superstrate layer at a distance of around 0.5 0 from the ground plane in order to increase bandwidth.

The parasitic patches are sized and spaced so that each one will resonate at a different near resonance frequency, increasing the antenna's bandwidth. Antenna efficiency, SLL, cross polarization, front-to-back lobe ratio, antenna size, weight, and cost are some of the factors thataffect how well a directional antenna performs.

Here, MSA is configured using hexagonal shaped radiating patch. The structure is designed to operate in the ultra-wideband frequency range of 1.6 to 2.4 GHz.

3. Proposed System

The development of wireless communication has recently accelerated due to improvements insemiconductor technology and signal processing techniques, and it has now established itself as a fundamental aspect of modern civilization. The dynamics of the working environment andworker mobility have been altered by wireless communication. Nowadays, professionals can work from anywhere and at any time thanks to communication systems like satellite communication, mobile communication, local multipoint distribution system, GPS, Radio- Frequency Identification (RFID), remote sensing, World Interoperability for Microwave Access networks (WiMAX), Wireless Personal Area Networks (WPAN), Wireless Local AreaNetworks (WLAN), Ultra-wideband (UWB) communication, etc. Every system, regardless ofthe application, needs more capability, greater performance, a smaller footprint, and—most importantly—lower development costs. As a result, new systems are occasionally proposed. As a result, the market for effective antennas for portable devices using wireless communication networks is enormous.

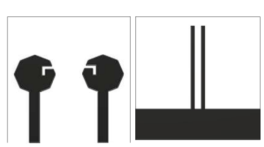
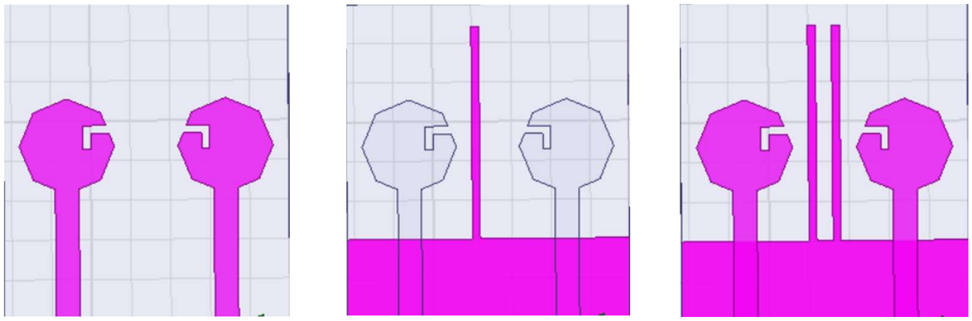


Fig. 3. MIMO antenna structure

4. Results &Discussion



Antenna 1 Antenna 2 Antenna 3

Fig.4.1 Geometry of proposed MIMO Antenna with Modification In Ground Plane

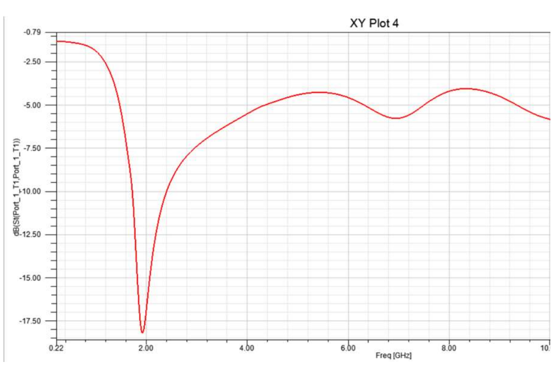


Fig. 4.2 Return loss verses Frequency of HMSA

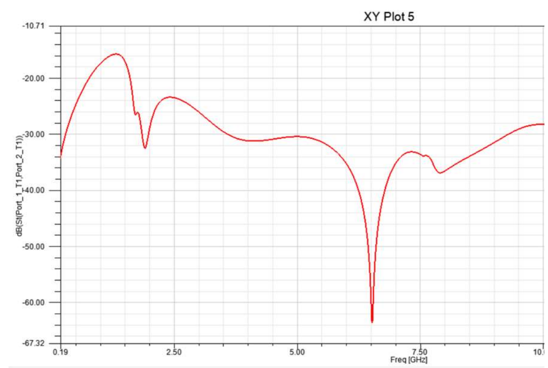


Fig. 4.3 Isolation verses Frequency of HMSA

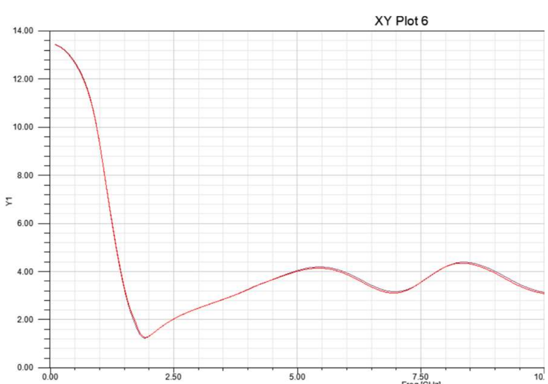


Fig. 4.4 VSWR verses Frequency of HMSA

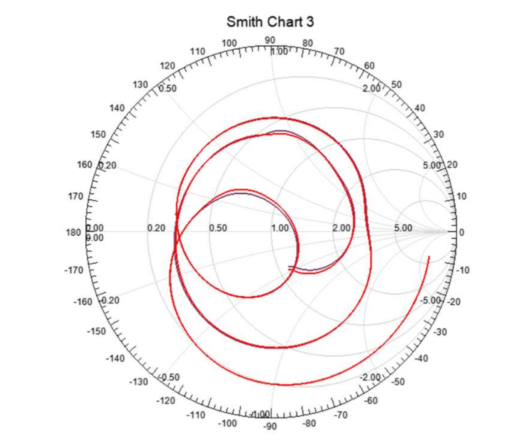


Fig. 4.5 Radiation Pattern of HMSA

	Freq [GHz]	dB(St(Port_1_T1,Port_1_T1)) Setup1 : Sweep	dB(St(Port_1_T1,Port_2_T1)) Setup1 : Sweep
1	0.100000	-1.297327	-39.460318
2	0.110000	-1.297993	-38.649333
3	0.120000	-1.298723	-37.903552
4	0.130000	-1.299517	-37.213180
5	0.140000	-1.300374	-36.570403
6	0.150000	-1.301296	-35.968900
7	0.160000	-1.302281	-35.403496
8	0.170000	-1.303331	-34.869902
9	0.180000	-1.304445	-34.364529
10	0.190000	-1.305623	-33.884345
11	0.200000	-1.306866	-33.426766
12	0.210000	-1.308173	-32.989574
13	0.220000	-1.309545	-32.570853
14	0.230000	-1.310983	-32.168935
15	0.240000	-1.312486	-31.782360
16	0.250000	-1.314055	-31.409844
17	0.260000	-1.315690	-31.050253
18	0.270000	-1.317391	-30.702579
19	0.280000	-1.319159	-30.365924
20	0.290000	-1.320995	-30.039483

Fig.4.6 Performance of the Designed in Data Table

5. LITERATURE SURVEY

Presents a new compact rectangular microstrip patch antenna with a superstrate element. This antenna operates at 5.6 GHz TM01 fundamental mode, which is suitable for WLAN applications. The patch area is reduced by 50% by adding slits on the ground plane. In order to compensate for the decreased gain due to the size reduction, a high permittivity superstrate is used with 4mm thickness and 5mm height from the antenna surface. The proposed antenna offers the advantage of occupying half the area of the non-modified rectangular patch while it possesses the same broadside gain of 8-11dB.

The trade-off is the additional antenna height due to the placement of the superstrate element. This paper presents a new compact rectangular microstrip patch antenna with a superstrate element. This antenna operates at 5.6 GHz TM01 fundamental mode, which is suitable for WLAN applications. The patch area is reduced by 50% by placing three rectangular slots on the ground plane. In order to compensate for the decreased gain due to the size reduction, a high permittivity superstrate is used with 4mm thickness and 5mm height from the antenna surface. The proposed antenna offers the advantage of occupying half the area of the nonmodified rectangular patch while it possesses the same broadside gain of 6-7dB. The trade-off is the additional antenna height due to the placement of the superstrate element.

6. Advantages of MIMO Antenna

The MIMO antenna has wide applications and few are listed below:

- Beam steering – MIMO offers the opportunity to electronically guide the directivity of the RF signal by controlling the signal propagating phase over multiple antennas.
- Increased data capacity
- The higher data rate can be achieved with the help of multiple antennas and SM (Spatial Multiplexing) technique. This helps in achieving higher downlink and uplink throughput.
- There is lower susceptibility of tapping by unauthorized persons due to multiple antennas and algorithms.
- The wide coverage supported by MIMO system helps in supporting large number of subscribers per cell.
- The MIMO based system is widely adopted in latest wireless standards viz. WLAN, Bluetooth

7. DISADVANTAGES OF MIMO ANTENNA

Through MIMO antenna provides variety of applications it lags with few properties and are listed below:

- The resource requirements and hardware complexity are higher compare to single antenna- based system. Each antenna requires individual RF units for radio signal processing. Moreover, advanced DSP chip is needed to run advanced mathematical signal processing algorithms.
- The hardware resources increase power requirements. Battery gets drain faster due to processing of complex and computationally intensive signal processing algorithms. This reduces battery lifetime of MIMO based devices
- MIMO based systems cost higher compare to single antenna-based system due to increased hardware and advanced software requirements.

8. APPLICATION

Hexagonal MIMO antenna operating at frequency of 7.5 GHz application for UWB application especially for security purposes. Normally UWB antennas have been used in mobiles so that if someone enters the home or trying to open the lock, the notifications will be popped up in the mobiles. Now with the help of Hexagonal MIMO antenna with defected ground structure there is more speed in transmission of data which is most important characteristics in wireless communication. With the help of this antenna when placed in mobile phones will convert 2D space into grid format such that it is more helpful in specifically spotting the lost item in the room for ex: car keys, chain, rings etc.

The objective of the paper is to design hexagonal MIMO Flexible antenna and determine the parameters such as (i)Directivity (ii). S- parameter (iii) Gain value at E and H planes (iv) VSWR (v) Radiation pattern (vi). Radiation pattern. MIMO techniques ensure a significant boost in the efficiency of wireless systems. MIMO systems are considered as an extension of antenna array to improve channel capacity, spectral efficiency and multipath fading.

9. Future Scope

Some potential future scopes for the 2*1 microstrip MIMO antenna at 5.8GHz for FR4 substrate and slits on the ground plane could be: Improving the isolation between the antenna elements to reduce interference and improve signal quality. Increasing the bandwidth of the antenna to support multiple frequency bands for different applications. Testing the antenna in real-world scenarios and analyzing its performance in various environments. Investigating theeffects of changing the substrate material, size, and thickness on the antenna's performance. Exploring the possibility of integrating additional features, such as polarization diversity, beamforming, and frequency reconfigurability, to enhance the antenna's capabilities. Conducting a cost-benefit analysis to determine the economic feasibility of mass-producing theantenna for commercial applications.

10. Summary

It is a radio-based wireless communication technology that allows the transmission of a huge amount of digital data over a broad range of frequency bands with extremely little power over short distances. In this section, the different UWB MIMO antennas are reported which includes modification in the radiating patches, ground plane (GP) and isolation techniques. UWB technology offers a frequency range of 3.1 to 10.6 GHz with channel bandwidths of more than 500 MHz [16]. For the decoupling of a small UWB MIMO antenna, a broadband neutralized line is employed. With a mutual coupling of less than −22 dB, this UWB MIMO antenna has covered the lower UWB range of 3.1–5 GHz. MIMO designs must display wideband features to meet the demands of increased spectral efficiency, provided that the reciprocal coupling between the radiating components is kept to a minimum. The decoupling network using two inverters and two connected split-ring resonators (SRRs) in provides excellent isolation between the ports.

11. Conclusion

Based on the design and simulation results, it can be concluded that a 2x1 microstrip MIMO antenna with slits on the ground plane and operating at a frequency of 5GHz to 6GHz on an FR4 substrate is a feasible option for wireless communication systems. The proposed antennaachieved a good return loss of -22.8dB.The radiation patterns of the two antennas are also consistent, making it a good candidate for achieving high gain and reliable communication. However, further testing and optimization are necessary to fully validate the performance of the antenna in real-world scenarios. Overall, the design and simulation of the 2x1 microstrip MIMO antenna provide a promising solution for achieving gain and reliable wireless communication in MIMO systems.

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