Design of Microstrip MIMO Antenna for 5G Communication

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Abstract. The need for quicker communication with high data rates, capacity, network availability, coverage, and low latency is developing as a result of expanding populations and technological advancements. This propels us into the following advanced generation. Today, in-depth study of 5G technology is becoming more popular. High data rate transmission and intelligent wireless services will soon be commercially available with the launch of fifth generation (5G) mobile communication. The technology of 5G is incredibly cutting-edge and is getting a lot of attention. In the world of 5G wireless networks, Multiple-Input-Multiple-Output (MIMO) technology is anticipated to be one of the essential technologies. MIMO is a ground-plan array with an indefinite number of antennas, but often 64 to 128. One type of interior low profile is micro strip microwave antenna operating between 1 GHz and 1000 GHz. For 5G metal frame smart phones, a broad band eight element MIMO (Multiple Input Multiple Output) array with high element enrichment is proposed in this research. The E-shaped and H-shaped slots make up the proposed MIMO antenna array. By modifying the E-shaped slots, the necessary resonances can be attained to increase the bandwidth. Additionally, a U-shaped slot is added between each antenna element to improve element isolation between the two antennas. **Keywords: High isolation, MIMO antenna, 5G**

I. INTRODUCTION

MIMO antenna technologies are the key to increase the network capacity. achieve high bandwidth connectivity .renders a complete wireless system ideal for video-intensive applications at very low power consumption using multiple inputs/multiple outputs (MIMO).recover high spectral efficiency(more bits per second per Hertz of bandwidth).achieve a diversity gain that increases the link reliability (reduced fading).

1.1 OVERVIEW OF MIMO MICROSTRIP ANTENNA FOR 5G

Numerous multi-element MIMO antenna arrays have received a great deal of attention for a mobile communication system because multiple-input multiple-output (MIMO) antenna systems can increase channel capacity and transmission rate under the constraint of fixed communication bandwidth. A MIMO antenna array for a 5G system requires more than six antenna units in comparison to the antennas in a 4G mobile communication terminal system. They typically operate in the microwave frequency range between 3400 and 3600 MHz, 4800 and 5100 MHz, and 5700 and 5800 MHz, which is below 6 GHz.

The design of multi-element MIMO antennas for 5G mobile communication terminal systems is particularly difficult. The primary issue of MIMO antenna design is to organize several antenna elements in a short space due to the limited size of mobile communication terminals, which necessitates that the antenna elements should be more isolated between the antenna parts and smaller in size. For 5G smartphone terminals, a few MIMO antennas have been suggested. T-shaped antennas are the most common type of antenna element chosen.

The most straightforward approach is to increase the distance between antenna elements in order to improve the isolation between MIMO antenna elements. But because of the mobile terminal system's restricted space, additional decoupling techniques are frequently required.

1.2 MULTIPLE INPUT MULTIPLE OUTPUT (MIMO)

Since MIMO uses multiple antennas at the transmitter and receiver and selects different signal routes for each antenna to enable the usage of multiple signal paths, it is essentially a radio antenna technology.

The capacity of a given channel can be significantly increased with MIMO wireless technology due to the usage of several antennas. With every pair of additional antennas added to the system, the number of receive and transmit antennas can be increased, linearly increasing the channel's throughput. As a result, MIMO wireless technology has become one of the most crucial wireless technologies used in recent years. As spectral bandwidth for radio communications systems becomes an increasingly important resource, To make better use of the bandwidth at hand, strategies are required. One of these methods is wireless MIMO technology. Improvements in channel throughput and robustness can both be achieved with MIMO. The additional routes can be taken advantage of by using MIMO. By enhancing the signal to noise ratio or expanding the link's data capacity, they can be employed to provide the radio link more robustness.

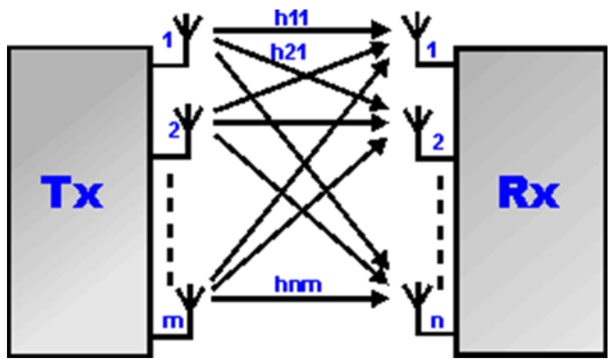

Figure 1.1 Architecture of MIMO

1.3 5G TECHNOLOGY

The fifth generation of mobile networks, or 5G. Following 1G, 2G, 3G, and 4G networks, it is a new international wireless standard. In order to connect practically everyone and everything together, including machines, objects, and gadgets, 5G enables a new type of network.

The goal of 5G wireless technology is to provide more users with faster peak data speeds of multiple gigabits per second (Gbps), low latency, increased stability, vast network capacity, and a more consistent user experience. New user experiences are enabled by increased performance and efficiency, which also connects new industries.

There are several reasons why 5G will be superior to 4G.

- 5G is significantly faster than 4G
- 5G has more capacity than 4G
- 5G has significantly lower latency than 4G
- 5G is a unified platform that is more capable than 4G
- 5G uses spectrum better than 4G

5G is a unified platform that is more capable than 4G.

While 4G LTE concentrated on providing substantially faster mobile broadband services than 3G, 5G is intended to be a unified, more powerful platform that enables new services like mission-critical communications and the vast IOT in addition to improving mobile broadband experiences. Additionally, 5G can natively support all spectrum types (licensed, shared, unlicensed), bands (low, mid, and high), a variety of deployment patterns (from conventional macro-cells to hotspots), and novel interconnection techniques (such as device-to-device and multi-hop mesh).

5G uses spectrum better than 4G.

In addition, 5G is intended to maximize spectrum use across a variety of regulatory regimes and bands, including low bands below 1 GHz, mid bands between 1 GHz and 6 GHz, and high bands known as millimeter wave (mm Wave).

5G is faster than 4G.

With peak data rates of up to 20 Gigabits per second (Gbps) and average data rates of more than 100 Megabits per second (Mbps), 5G has the potential to be much faster than 4G.

5G has more capacity than 4G.

A 100x increase in network efficiency and traffic capacity is what 5G is intended to support.

5G has lower latency than 4G.

5G offers a 10x drop in end-to-end latency down to 1ms, which enables it to provide more instantaneous, real-time access.

II. RELATED WORKS

K. Kanyakumari et al. (2016) said that the study of micro strip patch antennas has made great progress in recent years. Compared with conventional antennas, micro strip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the micro strip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility, and beam scanning omnidirectional patterning. Computer Simulation Technology (CST) microwave studio is used as the software environment to design and compare the performance of the antennas. They take some parameters should consider while designing the Rectangular and Circular antennas Based on the results and analysis, it is noted that the rectangular patch antenna shows higher return loss than the return loss of circular patch antenna.

D. Imran et al. (2018) this paper presents a micro strip patch antenna for future 5G-communication technology at centered frequency 38GHz and 54GHz having bandwidth 1.94GHz and 2GHz respectively with low cost substrate and small size patch best suited for miniaturized devices. They said about 5G antenna design and their formulas for width of the patch, length of patch, extension length and 5G design of array. This paper shows that we can achieve high Gain by using an array. This antenna has high Gain, Bandwidth, Radiation efficiency and directivity.

Mowafak. K. Mohsen et al. They said that four ports MIMO antenna is designed and implemented to achieve efficient bandwidth broadening. The characteristic evaluation of four ports dual-band MIMO antenna based on a micro strip patch operating at 1.8 and 2.6 GHz is performed. The fabricated antenna is tested via experiment and simulation. The designed antenna has the small ground plane and low mutual coupling is found to be potential for LTE applications. Superior diversity performance of the antenna is in terms of enveloping CCs and diversity gain is demonstrated. The simulated and measured results showed good agreement. An excellent pattern diversity, low correlation coefficient, high gain, superior directivity, and quite reasonable bandwidth in the above-mentioned range is achieved which is suitable for LTE bands application. Simulation is performed via CST microwave studio program, and experimental measurements are performed through Agilent Technologies E5071B VNA and the anechoic chamber.

Surajo Muhammad et al.(2019) This paper present the design and simulation of a single band micro strip patch antenna for 5G wireless application operating at 60GHz. The design is carried on Roger RT5880 with 2.2 dielectric, 0.0009loss tangent and 0.003 mm thickness using inset feeding. The overall dimension of the patch antenna is 2.9 × 3.5 mm2, two rectangular U-slot in conjunction with H-slot were loaded into the radiator to enhance the antenna bandwidth. The antenna is design and simulated and the analysis were carried out on CST studio. The realized gain of the antenna is 8.84dB with omnidirectional radiation pattern. The integration of the antenna can be done in devices where space is a major concern and can be used in future 5G wireless devices.

M.D. Madhanet al.(2019) In this paper, the various impacts on the antenna has been discussed. As per our survey, generally the micro strip patch antenna provides low bandwidth, low gain of nearly 5- 6dB, and thereby it provides low efficiency. So in order to improve these characteristics there are certain bandwidth and efficiency enhancement methods like Defected Ground Structure technique, making slots in the ground, slicing the corners of patch etc. are available. The role of DGS in the area of microwave and printed antennas is represented with numerous advances of DGS which involves multiple band bandwidth improvement, gain enhancement, cross polarization suppression, higher mode harmonics suppression, and circular polarization achievement. Considering the above mentioned impacts, our further aim is to develop an high gain efficient antenna which can provide 5G communication using the millimeter wave frequencies.

Garret Singh et al.(2013) In this paper, a new Defected Ground Structure (DGS) consisting of I-shape slot in ground has been presented to enhance the bandwidth of the Micro strip Patch Antenna (MPA).A novel antenna design working in C-band has been successfully implemented in this paper. The bandwidth of the micro strip patch antenna with same dimensions as mentioned above but without slotting is 126.2 MHz at fr6.2051 GHz with return losses (S11 =-27.72 dB). While micro strip patch antenna with I-Shape DGS provides bandwidth of 132.3 MHz and return losses reaches up to -46.75 dB as shown in Fig. 3. Thus it has been concluded that with I-Shape DGS, the bandwidth of the micro strip patch antenna is increased by 6.1 MHz. with reduction in ground plane area by 5%.The proposed antenna design is useful for satellite communications as well as in RADAR.

Pooja Siriya et al.(2019) In this paper they given detail about Selecting an appropriate substrate material for the design of micro strip patch antenna for various applications is a very important step in antenna design**.** This paper presents a work of various substrates materials used for the design of low cost inset feed rectangular micro strip antenna for WLAN, Wi Max, LTE, C-band and X-band applications. The substrates used are FR-4 epoxy, foam, polyethylene terephthalate (PET) and polydimethylsiloxane (PDMS). The antennas were designed, optimized and simulated using HFSS 15.0. Return loss, voltage standing wave ratio and gain analysis is carried out for these antennas. It is evident from the results obtained that the selection of substrate material in antenna design is very crucial and decide the performance of the antenna. The above antennas are useful for various applications such as WLAN, Wi Max, LTE, C-band and X-band. The choice of substrates varies according to the applications like flexible PDMS substrate can be used for wearable and conformal applications. Further work can include detailed study of material properties as it puts a great impact on all result parameters.

TommiHariyadiet al.(2018) they said that LTE is a standard of wireless communication access by using GSM/EDGE and UMTS/HSPA technology for high speed data transfer rates. LTE technology using MIMO system that can increase the data rate and capacity on sending and receiving simultaneously on a radio frequency channel so that the antenna for LTE band-3 works at 1.8 GHz also using MIMO structure. In this paper, the authors will propose a 2x2 MIMO antenna with directional radiation patterns that works at LTE band-3 using two types of patches, which are the parasitic and main patch to improve the gain. Antenna is designed with the micro strip feeding system with MIMO 2x2 main patch array elements that combined with parasitic patch in order to create a wider bandwidth and gain output The directional 2x2 MIMO micro strip antenna MIMO 2x2 with working frequency of 1.8 GHz for LTE application has been designed. The result from the simulation showed that the antenna worked in the 1.73-1.90 GHz frequency for the vertical polarization and 1.72-1.92 GHz for horizontal polarization; the antenna gain is 5-6.4 dBs.

XIAO-TING YUAN et al.(2020) In this paper, they presented an ultra-wide band multiple-input multiple-output (MIMO) antenna system with high element-isolation for the application in 5G metal-frame smart phones. We proposed T-shaped and C-shaped slots on the metal frame generating four resonances to enhance the bandwidth. They introduce modified H-shaped slots between each antenna-element to improve the element isolation of MIMO antenna system. The MIMO antenna system has a bandwidth of 58%, an element-isolation level over 18 dB and a good radiating efficiency over 40% across the frequency band from 3.3 to 6.0 GHz. Besides, the stable and diverse radiation patterns can ensure the ECC level lower than 0.05. What's more, the performance remains decent under the effect caused by user's hands and head in the practical applications. Consequently, the proposed MIMO antenna system is a reliable candidate for 5G applications immobile terminals.

HoudaWerfelli et al.(2016) This paper said about how to design a micro strip rectangular antenna in Advance Design System Momentum (ADS). The resonant frequency of antenna is 4.1GHz. The reflection coefficient is less than - 10dB for a frequency range of 3.1GHz to 5.1 GHz. The proposed rectangular patch antenna has been devise using Glass Epoxy substrate (FR4) with dielectric constant ($\epsilon r = 4.4$), loss tangent ($\tan \delta$) equal to 0.02. This rectangular patch is excited using transmission lines of particular length and width the conception and simulation of rectangular micro strip patch antenna that operates in UWB frequencies was successfully designed using advanced design system. From observing the return loss, VSWR, it is very clear that this antenna works on the designed UWB frequency range. This research, detailed the designing of our UWB rectangular antenna in the Advanced Design System and A soft High frequency structure simulator.

III. SYSTEM IMPLEMENTATION

3.1 MICROSTRIP ANTENNA

The most basic form of this micro strip antenna is a dielectric substratum with a ground plane at one end and a radiation patch on the other. Typically, copper or gold make up the patch drivers. The feeding lines and radiating parchment are typically photo etched within the dielectric layer the tiny strip patch antenna's configuration

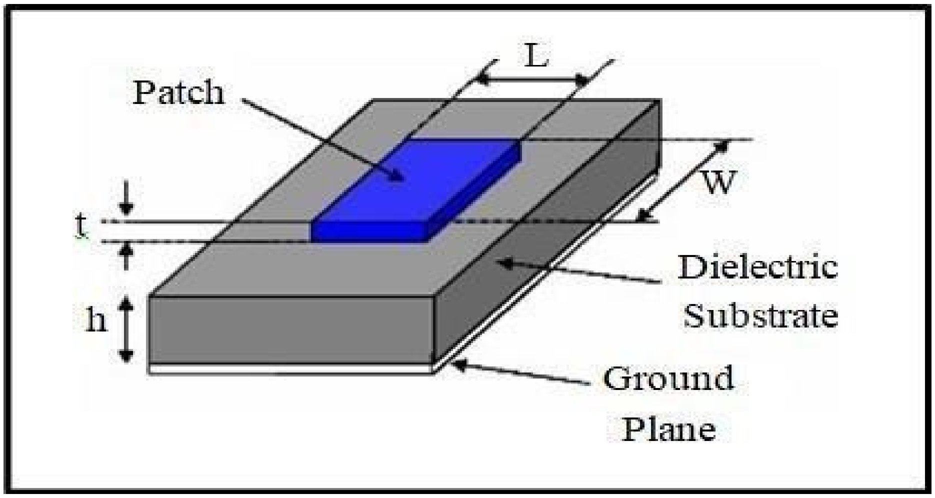

Figure 1. Architecture of Micro strip antenna

IV. EXPERIMENTAL SETUP

Antenna consists of a ground floor on one side and a radiating patch on one dielectric substratum. Typically, it is a conductor of electricity, such as copper or gold. For the patch, there are several typical shapes including square, rectangle, circle, and triangle. From the transmission line model for the rectangular patch, the three fundamental parameters for the design Micro strip patch antenna are obvious:

a. The antenna resonant frequency must be properly selected for operation (of).
b. Dielectric substrate constant (r): A high dielectric substrate limits the antenna readings.
c. Dielectric substrate height (h): It's crucial that the micro strip patch antenna isn't too big and has a maximum height of a few millimeter some applications (for example, mobile phones). The antenna configuration is depicted in figure 3.1 below.)

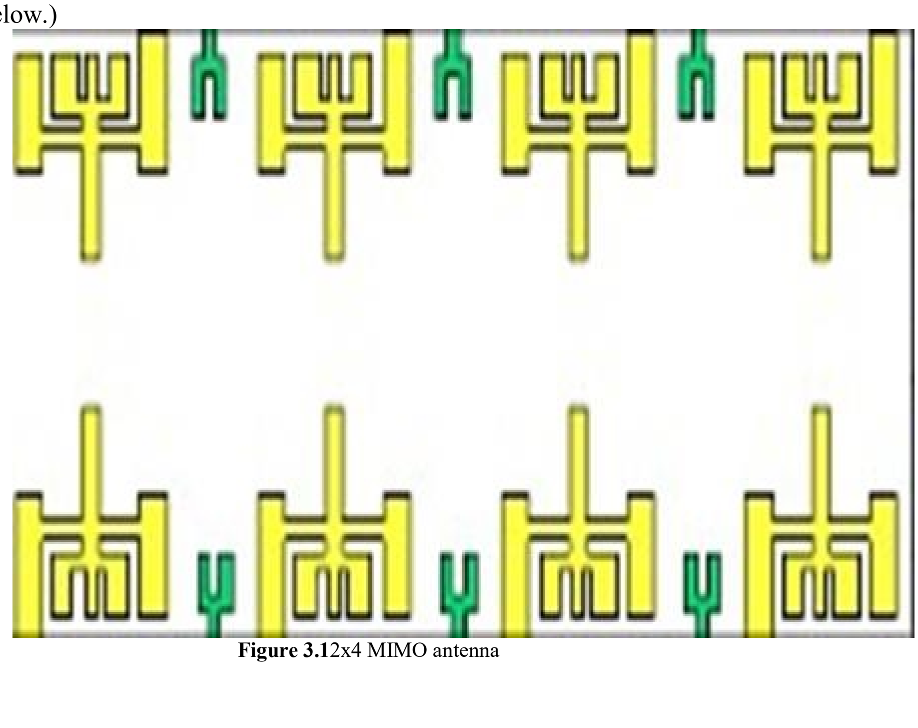

Figure 3.12x4 MIMO antenna

PARAMETERS	DIMENSIONS
Resonance Frequency	6GHZ
Substrate	FR4 epoxy
Height of the substrate	50mm
Width of the Patch	0.02mm
Length of the patch	110mm
Length of the substrate	175mm
Width of the substrate	1.63mm
Length of the ground	175mm
Width of the ground	0.035mm
Dieletric constant	4.4mm

Table 3.1 Dimensions of Proposed System

V. RESULTS AND DISCUSSION

5.1EXPERIMENT RESULTS

5.1.1. S PARAMETERS

Below is a discussion of the transmission coefficient, reflection coefficient, and S parameters of antenna design. With a reflection coefficient of less than -6 dB, the MIMO antenna design that is presented here can accommodate a broad frequency range from 3.3GHz to 6.0GHz (3:1 VSWR)

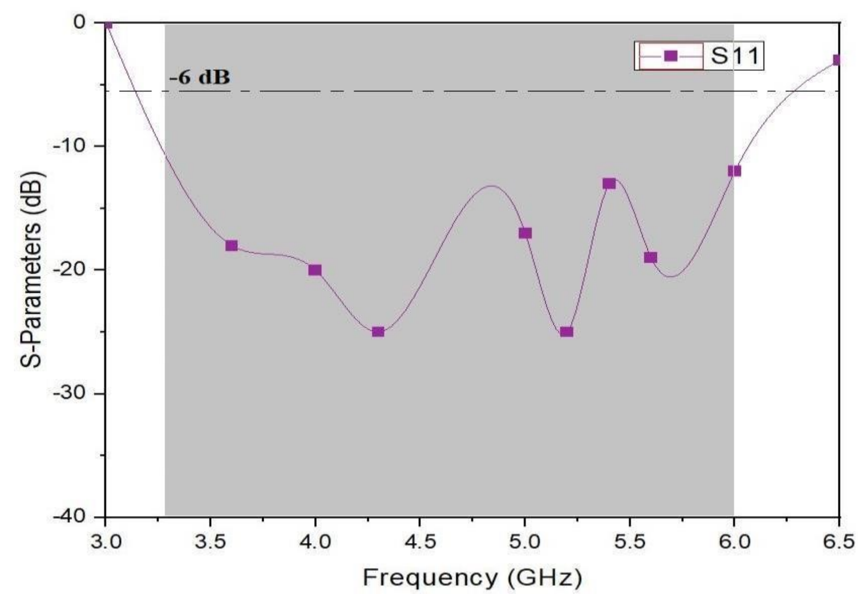

Figure 4.1Simulated Reflection coefficients

5.1.2 TRANSMISSION COEFFICIENT

According to Figure 4.2 and Figure 4.2, the transmission coefficient between any antenna pairs 1, 2, and 3 with or without a decoupling element. It is evident that whereas element isolation is only about 15 dB in the absence of decoupling structure, decoupling structure dramatically increases element insulation by more than -20 db. Because ports 1 and 2, 2 and 3, 1 and 5, 2 and 6, are adjacent to one another and also have stronger coupling than the other pair, the reflection coefficient between the ports S21, S32, S51, and S62 was examined. The simulated values are well-fitting, and the element's isolation is greater than -20 dB in the target frequency band

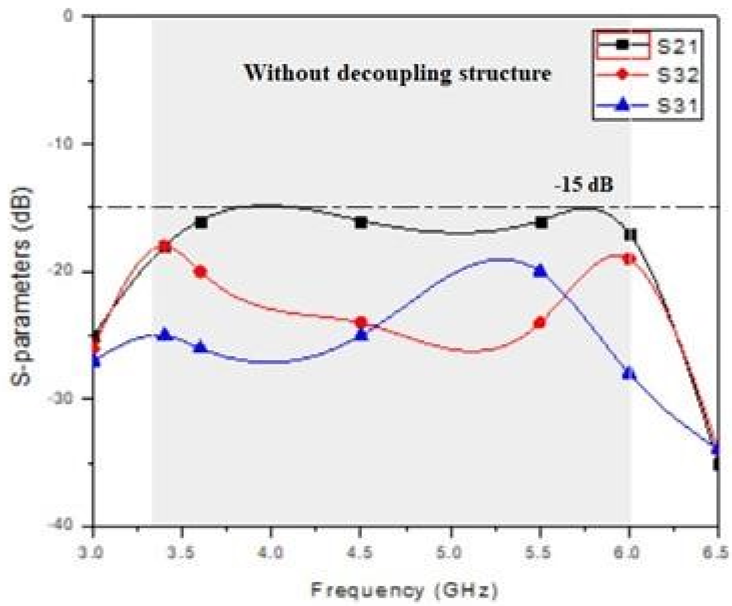

Figure 4.2Transmission coefficient without decoupling structure

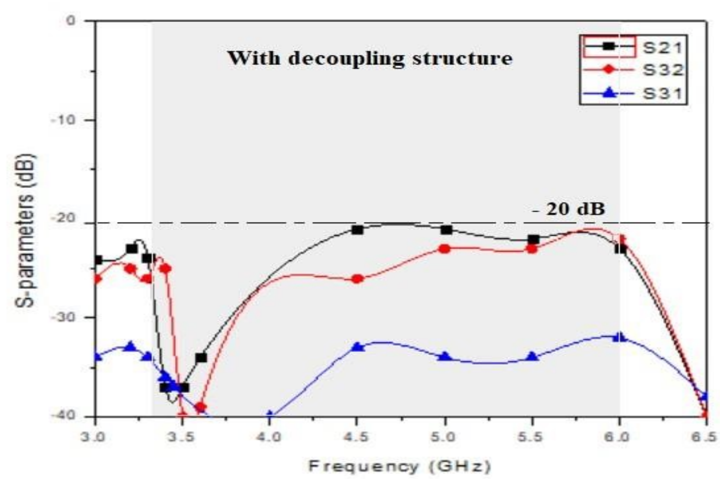

Figure 4.3Transmission coefficient with decoupling structure

5.1.3 EFFICIENCY

Figure 4.4, the simulated outcome of antenna efficiency, shows unequivocally that the antenna's efficacy is better than 80% on all target frequency bands

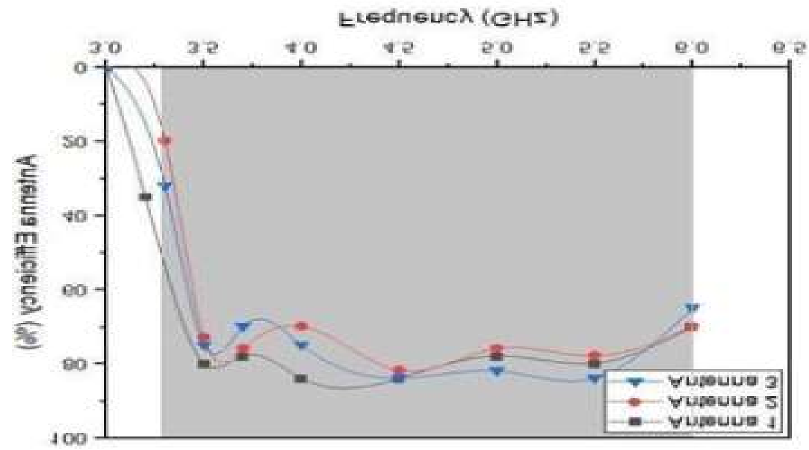

Figure 4.4 simulated result of antenna efficiency

5.1.4 ECC (ENVELOPE CORRELATION COEFFICIENT)

The proposed system's envelope correlation coefficient (ECC) was examined. Accessing the multiplexing and diversity of the MIMO antenna system requires taking ECC into account. The virtual ECC of antenna pairs 1 and 2, 2 and 3, 1 and 5, and 2 and 6 is shown in Figure 4.5. The preferred antenna configuration is two antennas close to one another. Envelope correlation coefficient of the symmetrical pair of antennas is not provided here for the sake of simplicity. The above figure shows a promising result because the ECC in the desired frequency range is less than 0.04

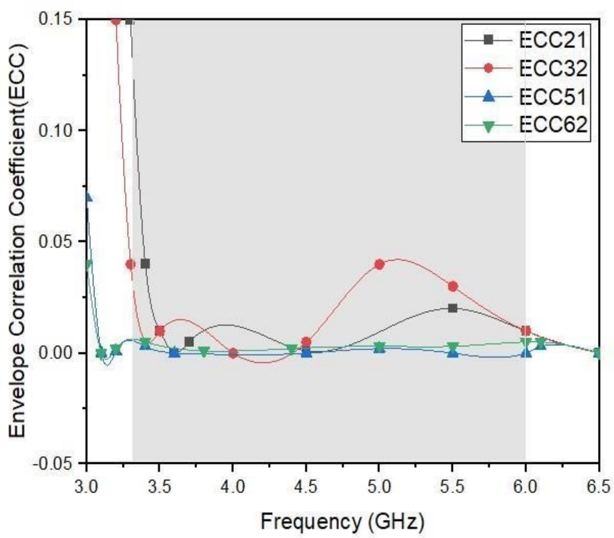

Figure 4.5 Simulated envelope correlation coefficient result ECC)

5.1.5. PERFORMANCE METRICS ON RADIATION PATTERN

Antenna 1's radiation pattern and antenna 2's radiation pattern were examined in this section. For the sake of simplicity, the radiation models of the additional antenna system components are not provided here in place of the symmetrical MIMO configuration. Figure 4.6 depicts the simulated 3D radiation patterns of Antenna 1 operating at three different frequencies, including 3.5GHz, 4.5GHz, and 5.5GHz, and Antenna 2 operating at three distinct frequencies, including 3.5GHz, 4.5GHz, and 5.5GHz. Figures 4.6 and 4.7 depict the maximal radiation path of antenna 1 as being inclined and showing the third quadrant or clock face at 3.5 GHz. The antenna 1's antenna patterns are also skewed at 4.5 GHz and 5.5 GHZ. Too the asymmetry of the field for antenna 1 serves as the rationale. Additionally, Fig. 14 shows that antenna 2's radiation varies to be more symmetric than antenna 1's across the frequency range. In actuality, the grounds of antennas 2 and 1 are rather symmetrical to one another. Due to the fact that antennas 1 and 2's overall radiation pathways do not intersect in the frequency region, the ECC is a reasonable 0.04 or less.

VI. CONCLUSION AND FUTURE TRENDS

6.1 CONCLUSION

In this project, an eight-part MIMO array antenna system is planned for use in 5G mobile applications. A section of the metal frame can be used to support the fifth generation MIMO array antenna's proper operation. The suggested antenna can be made with effective antenna isolation utilizing the decoupling technique, as demonstrated by simulation. Particularly, the proposed wideband MIMO antenna device exhibits acceptable isolation and a low envelope correlation coefficient, both of which are respectable for fifth generation MIMO antenna application. According to the computed results, the intended antenna array's working frequency range can cover 3.3 to 6 GHz with more than 20 dB isolation. A guarantee from the antenna will prevent the ECC level from exceeding 0.04. The proposed MIMO antenna technology is also effective for 5G applications on mobile terminals.

6.2 FUTURE WORKS

Micro strip patch antennas are well known for their effectiveness and long-lasting design, manufacture and design, light weight, etc. uses in various industries, such as in satellites, medical devices, and even military systems, such as rockets, planes, and missiles, etc. Micro strip antennas are widely used across all sectors and geographical areas, and because to their affordable production and substratum costs, the market for them is expanding. Standard antennas must be used in order to be most effective

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