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Design of Compact MIMO Antenna for 5G Applications

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Abstract: *The objective of the work is to design a compact MULTIPLE INPUT MULTIPLE OUTPUT (MIMO) antenna at sub-6GHz for 5G applications. Multiple-inputs and Multiple-output (MIMO) refers to the fact that it is a wireless technology, which is used to transfer more data at the same time between transmitter and receiver to increase the data rate and minimize errors. The antenna is designed by employing two rectangular stacked patch structures and slots, making the antenna resonate at a dual frequency band. It is well known that MIMO technology takes advantage of a natural radio-wave phenomenon called multipath where the transmitted information bounces off walls, ceilings,and other objects, reaching the receiving antenna multiple times via different angles and at slightly different times. MIMO antenna is suitable for increasing the SNR of mobile Communication systems. The channel capacity can be increased by improving SNR. The analytical study of antenna design is carried out using the governing micro strip patch equation. The main objective of this paper is to design a MIMO antenna with a single substrate , which is fed by microstrip lines . In this proposed project the bandwidth, Directivity ,return loss, VSWR, gain, efficiency, s-parameters and radiation pattern are simulated and determined . The characteristics of the proposed antenna are simulated using CST Microwave Studio 2021 Software.*

Keywords: 5G's High Data Rate, Microstrip Patch Antenna, Massive Multi-Input Multi-Output (MIMO), MIMO Antenna.

I. INTRODUCTION

The main aim of 5G technology is to provide low latency, high data speed, massive network capacity, reliability and high availability. Antennas are used in both transmitters and receivers. The number of wireless handheld devices is increasing tremendously. Antennas have been becoming a useful technology and most used topic in wireless communication systems. MIMO antenna requires a large amount of data transfer which is suitable for 5G application. The need for antennas supporting multiple bands as a part of communication in vehicular scenarios is exponentially increasing [1]. An antenna with more radiating elements tends to provide high signal quality as it can receive from all the directions[1]. The performance and range of MIMO require the support of both the station (mobiledevice) and the access point. It is well known that the MIMO Technology takes advantage of a natural radio-wave phenomenon called multipath, where the transmitted information bounces off walls, ceiling and other objects reaching the receiving antenna multiple times via different angles and at slightly different times[2].

A MIMO system often uses four antennas to make it more powerful. Various antenna parameters are considered like radiation pattern – it refers to the directional dependence of the strength of the radio wave from the antenna or other source , Antenna Gain – It is the ability of the antenna to radiate more or less in any direction compared to a theoretical antenna , Directivity – It is the power density of the antenna in its direction of maximum radiation in three-dimensional space divided by its average power density and power acquired – It is the power that is received by the antenna. In general we design antennas for 50 ohm input impedance. So , the impedance of the antenna has to be matched using a network and it has to be a lossless matching network [3]. A micro strip antenna offers various approaches to improve bandwidth for wideband applications and a micro strip patch antenna is one of the most favorable antennas these days because it has a very simple structure. In this paper we propose a compact MIMO antenna for 5G application that operates at Sub 6 Ghz frequency band. We use CST microwave studio suite 2019 to design the antenna. Once the antenna is implemented using the software we further design the antenna manually using the FR4 Substrate material. The proposed antenna design is anticipated to attain good pattern diversity, low correlation coefficient , high gain and quite reasonable bandwidth. This paper is put in order into 6 sections. In sect 2 literature survey of the paper is discussed. In sect 3 we talk about the existing system. In sect 4 system design and Hardware description are discussed. In sect 5 we focus on the software description and in sect 6 we examine the conclusion and result.\

II. EXISTING SYSTEMS

The existing system creates a way to design an "**DESIGN OF COMPACT MIMO ANTENNA FOR 5G APPLICATIONS**". This existing antenna is used to reduce power loss. It operates at the range of 2.4 GHz and 4.2 GHz. The antenna is designed by employing two rectangular stacked patch structures and slots, making the antenna resonate at dual frequency bands. The analytical study of antenna design is carried out using the governing microstrip patch equations. The adjacent antennas in the MIMO configuration are positioned orthogonal to each other, thereby exhibiting better isolation between the antenna elements. The overall dimension of the MIMO configured antenna design is 60 mm × 60 mm × 1.6 mm, which is highly compact and is a suitable candidate for deployment of Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and Vehicle to Network (V2N) scenarios. The base station isolates itself while it directs the antenna gain to communicate and this system achieves the beam forming. The existing system is also used in autonomous vehicles, drones, satellite communication, etc.

III. PROPOSED SYSTEM

Antenna Geometry

The patch dimension for dual-band antenna was determined using the following Equation,

$$W = c/2fo((\varepsilon r + 1)/2)^{-1/2} \text{ (1)}$$

Where c is the speed of light (3 x 108m/s), f is the antenna's working frequency,
W is the width of the patch, and εr is the dielectric loss of material. The length of the patch is determined using,

$$\varepsilon eff = 4.3 + 1/2 \; + \; 4.3 + 1/2[1/(1 + 12(1.57 * 10^{-3}/17.72 * 10^{-3}))] \text{ (2)}$$

$$L \; = \; [c/2fo\sqrt{\varepsilon eff}] \text{ (3)}$$

The dimension of the required ground plane is determined using the equation which is given by,

$$Lg = 6h + L \text{ (4)}$$

Where Lg is the Length of the ground, h is the substrate thickness, and L is the Length of the patch.

$$Wg \; = \; 6h + w \text{ (5)}$$

Where Wg is the width of the ground, h is the substrate thickness, and w is the Width of the patch.

This proposed antenna is designed for next generation vehicular Communication mobile Communication and wireless Communications. This system is designed to operate at 5G band is sub 6 GHz Frequency.The Patch Antenna structures and slots,making the antenna resonate at a dual frequency band.The channel capacity can be increased by improving SNR. The analytical study of antenna design is carried out using the governing micro strip patch equation.In this proposed project the bandwidth , Directivity ,return loss, VSWR, gain, efficiency, s-parameters and radiation pattern are simulated and determined.5G can also deliver much lower latency for a more immediate response and can provide an overall more uniform user experience so that the data rates stay consistently high even when users are moving around.This proposed system is expected to achieve good pattern diversity, Low correlation coefficient, high gain and quite reasonable bandwidth.This antenna requires a large amount of data transfer which are suitable for 5G mobile Communication .

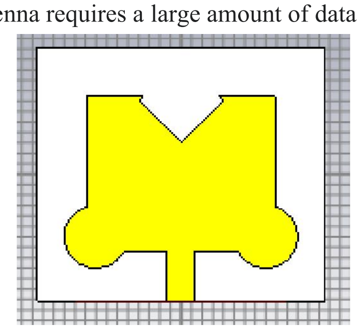

Fig 1: Front view of MIMO antenna

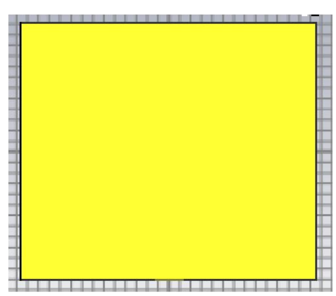

Fig 2: Ground Plane

IV. RESULTS AND DISCUSSIONS

The proposed antenna was fabricated. The simulated results of the proposed antenna were obtained through CST Microwave Studio Version 19 and its S-parameters were measured and the corresponding results will be presented below.

The reflection coefficient is also referred to as return loss or **S_{11} parameter**. The below figure indicates the return loss achieved by the proposed antenna. The return loss of -23.09 dB at 4.4 GHz and -32.40 dB at 6.9 GHz. For proper working conditions of the antenna, the return loss has to be less than -10 dB.

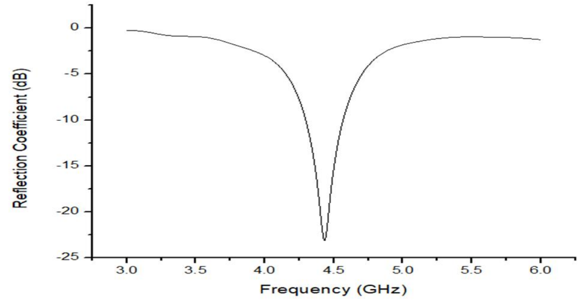

Fig 3: Reflection Coefficient of MIMO antenna

Reference impedance is a number that is used to define S parameters. If you have S parameters and you want information about voltages and currents (or vice versa), you need the reference impedance.

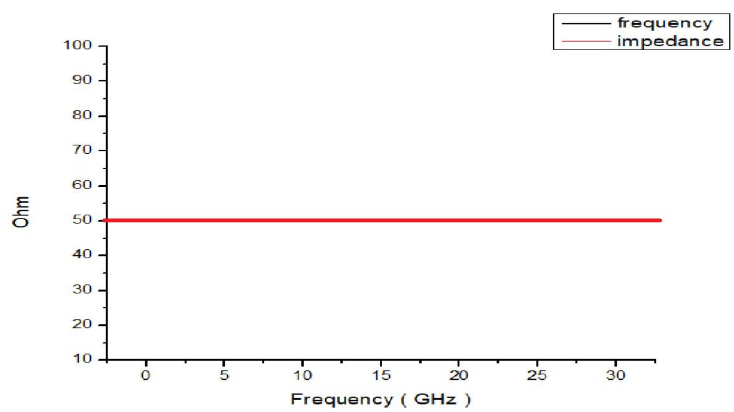

Fig 4:Reference Impedance of MIMO antenna

VSWR is the **voltage standing wave ratio** that determines the amount of power reflected from the antenna. The value has to be less than 2, but its ideal value is At 4.4 GHz, the VSWR measured is 1.1545 and at 6.9 GHz, it is measured as 1.0491.

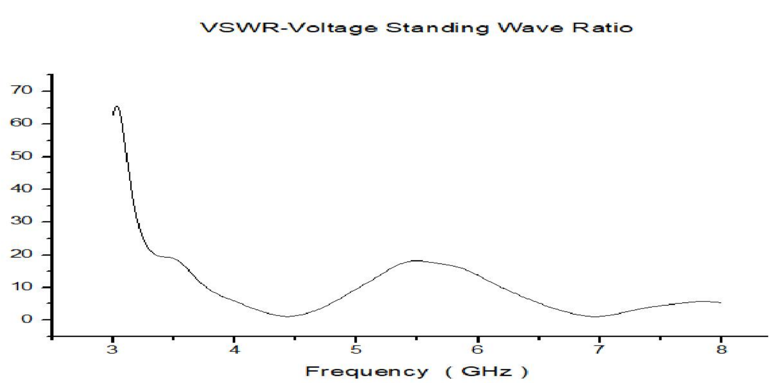

Fig 5: VSWR of MIMO antenna

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Antenna Efficiency is the ratio of power radiated (Prad) by the antenna to the power supplied (Ps) to the antenna. The efficiency of an antenna is usually measured in an anechoic chamber where an antenna is fed with some power and the strength of the radiated electromagnetic field in the surrounding space is measured. Radiation efficiency is another important parameter to describe how efficiently an antenna transmits and receives RF signals, which is defined as the ratio of the total power radiated by an antenna to the total input power received from the generator.

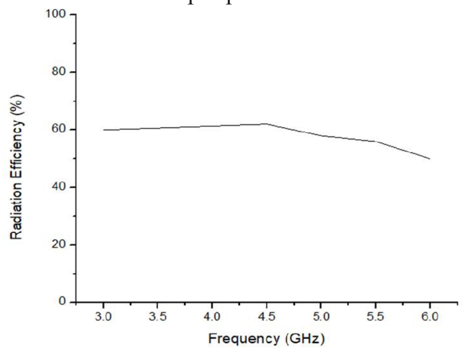

Fig6: Radiation Efficiency

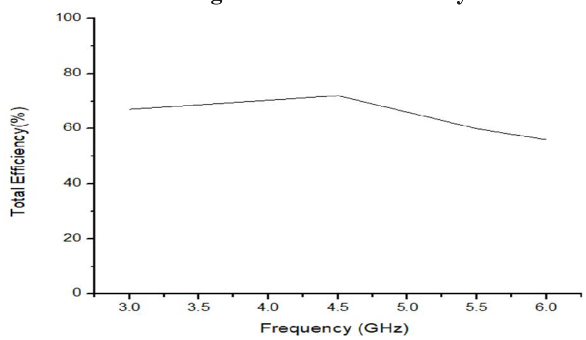

Fig 7: Total efficiency

Directivity:

The **directivity** of an antenna is the ratio of the maximum power density $P(\theta,\varphi)_{max}$ to its average value over a sphere as observed in the far field of an antenna.

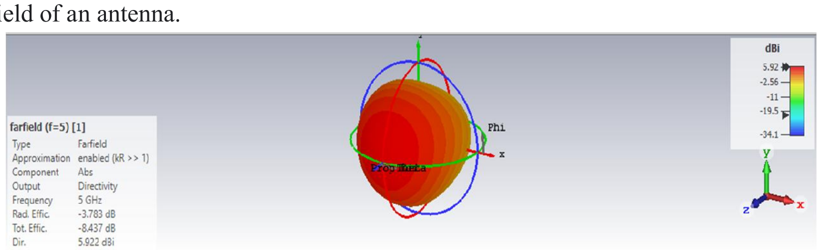

Fig 8: Directivity of MIMO antenna

Farfield Pattern:

Fig 9: Farfield pattern of MIMO antenna

Surface current:

Radiation from a micro strip antenna can be determined from the field distribution between the patch metallization and ground plane. Alternatively, radiation can be described in terms of the surface current distribution on the patch metallization. The surface currents are used to model the micro strip patch and the volume polarization currents are used to model the fields in the dielectric slab.

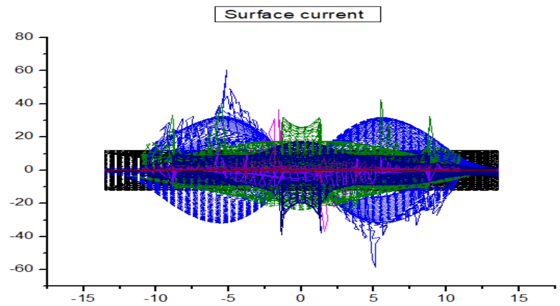

Fig 10: Surface current of MIMO antenna

Simulated result of the antenna

Parameters	**Simulated result**
Return loss	-23.09 dB
VSWR	1.154
Gain	5.93dBi
Impedance	50 ohm
Directivity	5.922dBi

V. CONCLUSION

The compact MIMO patch antenna is used in 5G applicaions. It is also used for mobile communication, vehicular communication and wireless communication. This antenna is designed using CST microwave studio suite 2019. Our proposed system operates at a SUB-6Ghz frequency range. Various antenna parameters are considered in our paper. Parameters such as s11 parameter, VSWR, Directivity, antenna gain, efficiency and impedance. The proposed system has better VSWR, Return loss and Directivity than the existing system.

The simulated results are

- S11 parameter - -23.09 dB at 4.4GHz
- VSWR - 1.1545 at 4.4GHz
- Directivity - 5.922dBi
- Total efficiency -
- Impedance - 50 Ohm

The simulated and measured values are tabulated and compared with each other and the proposed antenna is used for further applications. This proposed system is also used in MIMO technology and can be used in LTE and LTE advanced radio networks for improving network efficiency. One of the common uses of MIMO technology today is wireless LAN. Wireless routers with multiple antennas have become common nowadays. This antenna can also be used in the internet of things. One of the advantages of the MIMO antenna is that it can be used to achieve high data rate. It also requires less antenna elements. It has higher capacity and less bit error rate. In our proposed system we use only one patch antenna. In the future work we will be adding another three patches.

VI. ACKNOWLEDGMENT

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