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Design of Patch Antenna operated at mm Wave Frequency for MIMO Communication

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ABSTRACT

In today world more than five billion wireless devices are currently being in use for voice and data transmission. With increasing the wireless devices the data rate also increasing with bandwidth. Now for minimize the error and optimize the optimize the data speed MIMO technology is used. The efficient implementation of MIMO requires efficient compact antenna. The compact microstrip patch antenna is designed for MIMO communication system using HFSS software. The designed antenna operates in mm wave frequency and implemented in hardware that provides enhanced bandwidth and data rate which is that fulfill the requirement of the 5G communication.

Keywords: MIMO, HFSS

I. INTRODUCTION

Nowadays the mobile data rate is increasing tremendous, so the fifth generation frequency is necessary to utilize the huge amount of spectrum in the millimetre wave frequency to extraordinary increase communication efficiency. The mm Wave frequency is used in communication systems undergoes high losses and blockages. These losses in mm Wave communications attains several challenges to fully exploit the potential of mm Wave frequency. To overcome these challenges, we carry out a view of existing solutions, and proposed the design for mm Wave frequency for communication.

A. Antenna

An antenna is a transducer that converts radio frequency fields in to alternating current or vice versa. Antenna plays a important role in the operation of all radio quipment. They are used in wireless local area network, mobile telephony and satellite communication.

B. Microstrip Patch Antenna

The Microstrip patch antennas are low profile, comfortable to all two dimension and nonplaintiff surface, simple and low cost to manufracture using modern printed circuit technology, it is easy to design for any structure and shape. There are many substrate that can be used for the design of patch antennas, and their dielectic constants(εr)are usually in the range of 2.2 to 22. For because of the low dielectric constant which provide better efficiency. To be reached between good antenna performance and circuit design. The microstrip antennas are also said to as patch antennas. The patch of the microstrip antenna may be the various shapes such as square, rectangle, thin strip, circular, elliptical, triangular or any other configuration.

C. mm Wave Frequency

Millimeter wave is also known as the super high frequency, it is used for the high-speed wireless and satellite communications. Millimeter wave is now

under the research only, so some of the rooms of frequency only allowed by the ITU, If the mm wave frequency is developed it can be used for the high speed data rate and wireless broadband application and it allows data rate up to 10 Gbps.

D. Metameterial Structure

Inside a dielectric material, the free space wavelength of an antenna is scaled down by a factor of, where is the relative electric permittivity and is the relative magnetic permeability of the material. Thus, the size of an antenna can be significantly reduced by choosing a high or high material. Though miniaturization can be achieved using high materials, it comes at the cost of increased dielectric losses that can significantly affect antenna efficiency.

On the other hand, materials that exhibit a high in the microwave region do not exist in nature and designers have been compelled to use lossy high materials when antenna miniaturization is a key design requirement. Fortunately materials that exhibit high, or magnetic permeability enhanced meta-materials, can now be artificially engineered to lead to smaller antennas without compromising other design criteria.

E. MIMO Communication

MIMO is an technology used in antenna design which consists of multiple antennas at receiver and transmitter for the wireless communications. The antennas at transmitter and receiver used in the communication system are combined to minimize errors and increase the data rate. MIMO technology is used in the applications such as television, wireless communication and also the mobile communication.it is also used in the modem which consists of the two frequency for the high data transmission which negotiate with the cell tower.

II. DESIGN MODELS FOR MICROSTRIP ANTENNA

The most popular model for the design analysis of microstrip patch antennas are the transmission line model which is simple and give good physical insight, in this paper the transmission line model is used to design an rectangular microstrip antenna, this design is simply based on the empirical equations governing the transmission line model. The basic parameters of the patch antenna are obtained from calculations carried out using the appropriate equations. The main aim is to obtain data for different values of frequency of operation. The parameters of interest include the effective dielectric constant (εreff), patch width(w),patch length(L) and wavelength (λ). Analysis of the different scenarios is carried out using the plots generated from the table of the calculated results. The results can be used to determine certain trade off issues that may bother on any choosed parameter at the expense of the others.

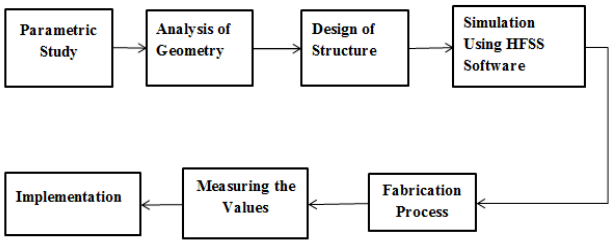

Figure 1. Design Flow

The above figure 1 represents the general design flow of the microstrip patch antenna. That consists of the flow of the design used for designing the proposed patch antenna by using the HFSS software. The proposed antenna is designed by using the desired dimensions obtained by using the given formulas.

Wavelength:

$$\lambda = \frac{c}{f_0} \quad (1)$$

c- velocity of light

fo- frequency used

Width of the patch:

$$w = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (2)$$

Effective dielectric constant:

$$\frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\left[\frac{-1}{2}\right]} \quad (3)$$

εr -dielectric constant
h - thickness of the substrate
w - width of the patch

Incremental length:

$$\Delta L = 0.412h * \frac{\left[(\varepsilon eff + 0.3) * \left(\frac{w}{h} + 0.264\right)\right]}{\left[(\varepsilon eff - 0.258) * \left(\frac{w}{h} + 0.8\right)\right]} \quad (4)$$

εeff- effective dielectric constant
h- thickness of the patch

Effective length:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (5)$$

Length:

$$L = L_{eff} - 2\Delta L \quad (6)$$

Ground:

Length: $L_g = 6h + L$ (7)

Width: $w_g = 6h + w$ (8)

Guided wavelength:

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_{reff}}} \quad (9)$$

Radiation box:

$$\frac{\lambda_g}{6} \quad (10)$$

Feed:

length: $L_f = \frac{\lambda_g}{4}$ (11)

width: $w_f = \frac{2h}{\pi}\left\{B - 1 - \ln(2B - 1) + \left(\frac{\varepsilon_r - 1}{2\varepsilon_r}\right)\right\} * \left\{\ln(B - 1) + 0.39 - \left(\frac{0.61}{\varepsilon_r}\right)\right\}$ (12) The rectangular shaped microstrip patch antenna is designed by using the metameterial substrate which is used to provide the negative resistance characterists and the substrate used is RT Duroid that consists of the dielectic constant is 2.2, and the feeding used here is the microstrip line feeding which is used to reduce the losses and the operating frequency is 29.5 GHz.

TABLE I DIMENSIONS OF THE PATCH ANTENNA

PARAMETERS	VALUES(mm)
W	4.01
ε_{eff}	2
H	0.41
ΔL	0.21
L_{eff}	3.59
L	3.16
Lg	5.65
Wg	6.51
Λg	7.19
Lf	1.79
Wf	1.86

The above table 1 represents the dimension of the proposed microstrip patch antenna for the frequency of 29.5 GHz.

III. RESULT ANALYSIS

Results and discussion deals with the results and discussion of the rectangular shape microstrip patch antenna. All the requirement of the design is illustrated individually and the output is given.

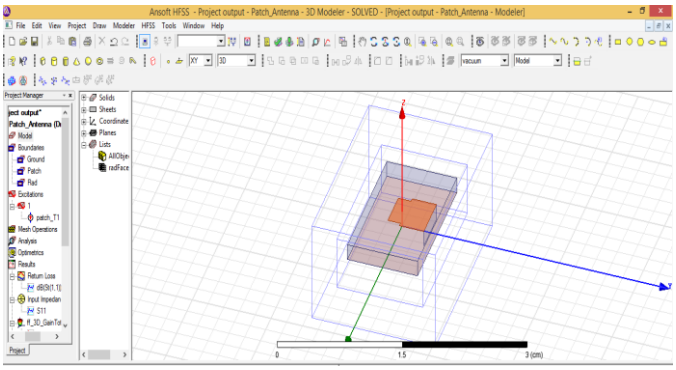

Figure 2. Design by using HFSS software

The above diagram describes the design of the microstrip patch antenna and the length and width of the antenna is selected as per the calculation depends

upon the frequency used, here the frequency used is the millimeter wave frequency.

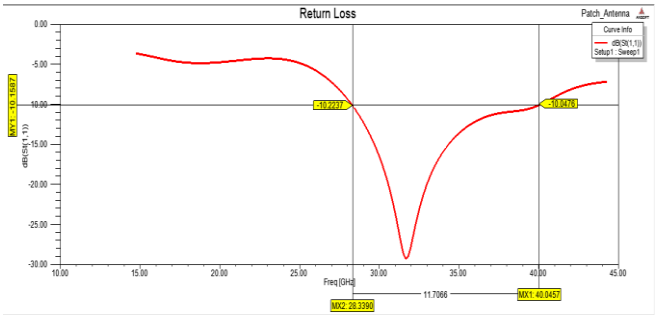

Figure 3. Return Loss

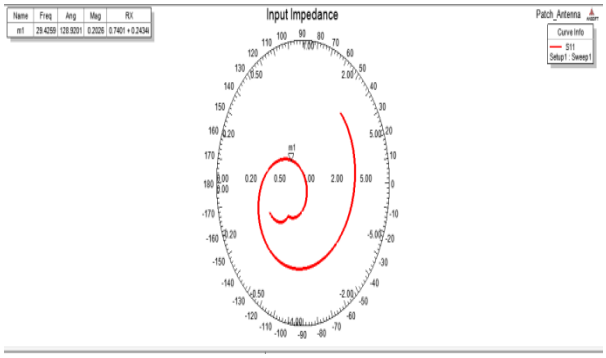

Figure 4. Input Impedence

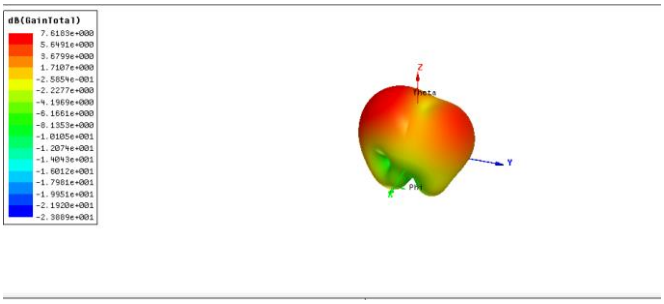

Figure 5. Gain of the Designed Antenna

IV. Hardware Design

The designed microstrip patch antenna is implemented in hardware design, which operates at the frequency of 29.5GHZ.

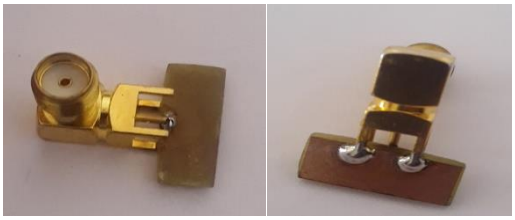

Figure 6. Hardware Design of the Antenna

V. CONCLUSION

The rectangular shaped microstrip patch antenna is designed by using the metameterial as the substrate at the frequency range of 29.5GHz to increase the bandwidth and the data rate and the data rate is increased up the 10 Gbps, so the number of users can be increased with high efficiency.

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