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Design And Simulation Of Dual Band U-Shaped Patch Antenna For Millimeter Waves

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Abstract—

In this paper we are designing and simulating the dual band antenna by using different designing parameters equations. We are designing a u-shaped antenna at a frequency of 25GHz and 40GHz.Thesubstrate used for this design is rogers RT (5880)/ Duroidwhich has a dielectric constant of 2.2 and has a losstangent value of 0.0009. The substrate dimensions are 7.3mmx8.5mmx1mm and for the ground plane the dimensions are 7.3mmx8.5mm. We are using micro strip feeding technique for this design.And to simulate the proposed antenna we are using ANSYS HFSS software.

Keywords— u-shape antenna, HFSS software.

1. INTRODUCTION

Now-a-days the usage of wireless cellular networks is increased.We are using this wireless cellular networkin some applications.Those aremobile, tablets and this can also used for video streaming which gives a high quality for data communications. When compared with fourth generation the cellular network capacity increased rapidly in these days.By using the cellular networkwe can connect many devices for wireless services. In thismost of the communication systems operates at frequency of 3GHz, the availbility of spectrum is becoming insufficient, especially at microwave bands. So, it becomes necessary to operate the system at millimeter wave bands which lies in between 20GHz to 90GHz.We know that 5G abbreviates for 5^{th} generation wireless systems. For this design we are using rogers RT(5880)/Duroid substrate which consist of a dielectric constant of 2.2.The material has low electric loss which gives a very goodreturn loss values and vswr and gain when compared with other substrates. In this firstly we will design a micro strip patch antenna which has special features because of it's less weight, low profile andthis is best suited for both the planar and non planar surfaces. In the proposed antenna the substrate is inserted in between ground plane and patch. For the ground plane and patch the material used is metal. In this we are using micro strip line feeding technique.

2. LITERATURE SURVEY

With the help of reference[1] we will get a overview about 5G mobile communication. Compared with existing 4G communication system, a large number of smart and heterogeneous wireless devices will be accessing 5G mobile systems. Typically it ranges from 6GHz to 100GHz. The majority of the communication systems are operating at a frequency greater than 3GHz.So,the spectrum availability is getting reduced. So, it is becoming necessary to operate at millimeter wave bands which lies in between 20GHz to 90GHz[2]. In reference paper[3] the speed is 1Gbps for 4G standards and the connectivity speed is 25Mbps. Mostly the fabrication of antenna's are done by the available substrates for operating frequency over 10GHz.[4],rogers RT(5880)/ Duroid is used because it has high tensile strength and it gives excellent return values.[5]The elementary micro strip patch antenna has special features like small scale, light weightand best suited for both planar and non planarsurfaces. In reference paper [6] a rectangular micro strip patch antenna is designed at 5.2GHz which gives a return loss value of -12.13dB. In this the substrate has high loss tangent value. In reference paper[7] an antenna is designed whose bandwidth is 10GHz.In reference paper[8], micro strip patch antenna is designed at a frequencies of 38GHz and 54GHz which results a bandwidth of 1.94GHz and 2GHz.In reference paper [9-10] a normal U-shape antenna is designed which operates at dual band with bandwidth of 34.27% and 14.67%.The efficiency of antenna is 90.7%.In the reference paper[11] an E-slot and H-slot antenna is designed at a frequency of 60GHz. Their gain value is 5.4dB. In reference paper [12] a U-shaped slot antenna is designed at a frequencies of 1.32GHz and 2.31GHz which gives a return loss value of -18dB and -27.2dB. In paper [13] an E-shaped antenna is designed at a frequency of 2GHz which gives a return loss value of -16.72dB. The proposed U-shaped antenna works at a frequency of 25GHz and 40GHz which gives a higherbandwidth,low insertion loss, and low return loss.

TABLE 1

DIFFERENT RADIATION PARAMETERS

Reference papers	Resonant Frequency (GHz)	Gain (dB)	Reflection Coefficient (dB)
[6]	5.2	3.02	-12.13
[7]	28,38	3.75,5.06	-43,-18
[8]	38,54	6.9,7.4	-15.5,-12
[9-10]	1.909,2.66	2,4.2	-40.5,-30
[11]	28,38	5.8,5.5	-45,-20
[12]	1.32,2.31	Upto 6	-18,-27.2
[13]	2.0	6.07	-16.72
U-Shaped antenna	25,40	8.07,5.92	-21.26,-31.23

3.ANTENNA DESIGN

3.1 Analysis for substrate material:

The dielectric material which is used in microstrip antenna supports both electrically and mechanically. In this work we are designing an antenna to operate it at millimeter range frequencies. The loss tangent value of rogers RT (5880) /Duroid is (0.0004) low when compared with FR4 epoxy (0.013). Hence rogers RT (5880)/ Duroid is used for designing this antenna.

3.2 Analysis for Feeding technique:

Micro strip patch antenna consist of many feeding techniques. It consist of two feeding techniques they arenon contact feeding techniques and contact feeding techniques. For non contact feeding technique the fabrication is difficult. So, in this design we are using contact feeding technique. There are two types in contact feeding technique they are coaxial line feeding and microstrip line feeding. In this design we are using microstrip feeding technique which is simplest and apt for micro wave frequencies.

3.3 Analysis for structure of antenna:

In the design the shape of reciving element is U-Shape. The dimensions of the U-Shaped patch has to met with the dimensions calculated using design equations at the desired operating frequency. The area of U-Shaped patch is equal to the area of rectangular patch.

Operating frequency (fo) =25GHz,40GHz

Relative permittivity of substrate (Ɛr) =2.2

3.4 U-Shaped antenna design:

The dual band antenna is designed with a substrate dimensions Lg× Wg and the material used in this design is rogers RT (5880)/ Duroid which consist of a dielectric constant of 2.2 and the standard height of substrate is 0.508mm . The dimensions of the substrate material is 7.3mm×8.5mm×1mmand forthe ground plane dimensions are 7.3mm×8.5mm. In this we are using transmission line feed technique it is also known as micro strip line feed and it is used to design the microstrip patch antenna.

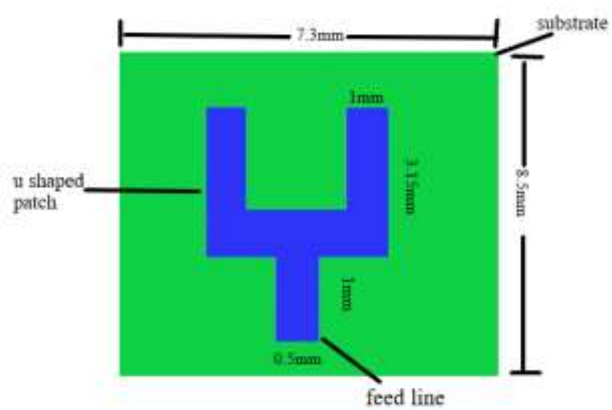

Fig 1: U-Shaped micro strip patch antenna

Theoretical Calculations:

Substrate used is rogers RT(5880)/duroid

Relative permittivity of substrate(Ɛr)=2.2

Frequency(f)=25GHz

Wavelength(λ)=c/f

Where c is the velocity of light=3x10^8m/s=3x10^11mm

λ=3x10^11mm/25GHz

λ=12

Width(W)=$\frac{c}{2f} \times \sqrt{(\frac{2}{\varepsilon r+1})}$=6x0.8=4.8mm

Length(L)=Leff-2ΔL
where Leff is the effective length

ΔL is the normalized extension

ΔL=0.412h$\frac{(\varepsilon reff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{W}{h}+0.8)}$

h = Thickness=0.6

Ɛreff=$\frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1 + 12\frac{h}{w}\right]^{\wedge(-\frac{1}{2})}$ =1.6+0.6(0.664)=1.97

Effective dielectric constant =1.97

ΔL=0.412(0.6)$\frac{(1.97+0.3)(\frac{4.8}{0.6}+0.264)}{(1.97-0.258)(\frac{4.8}{0.6}+0.8)}$=0.2472$\frac{18.75}{15.06}$=0.3mm

Leff=$\frac{c}{2f\sqrt{\varepsilon reff}}$=$\frac{3\times10^{\wedge}11mm}{2\times25\times10^{\wedge}9\times\sqrt{1.97}}$=4.27mm

L=4.27mm-2(0.3mm)=3.67mm

Substrate length(Lg)=L+6h=3.67+6(0.6)=7.27mm

Substrate width(wg)=w+6h=4.8+6(0.6)=8.4mm

Substrate height=0.6mm

Guided Wavelength(λg)=$\frac{\lambda}{\sqrt{\varepsilon reff}}$=$\frac{12}{\sqrt{1.97}}$=8.55mm

Feed length=Transmission Length=$\frac{\lambda g}{4}$=$\frac{8.55}{4}$=2.13mm

Radiation box length=$\frac{\lambda g}{6}+\frac{\lambda g}{6}+Lg$=10.12mm

Radiation box width=$\frac{\lambda g}{6}+\frac{\lambda g}{6}+Wg$=11.25mm

Radiationbox height=$\frac{\lambda g}{6}+\frac{\lambda g}{6}+h$=3

4. SIMULATION RESULT

4.1 S parameters plot:

The amount of light which is reflected back towards the source is called return loss which is also called as reflection coefficient and it is expressed in decibels. The proposed antenna has the return loss of -21.26dB and -31.23dB at 25GHz and 40GHz which is shown in below figure.

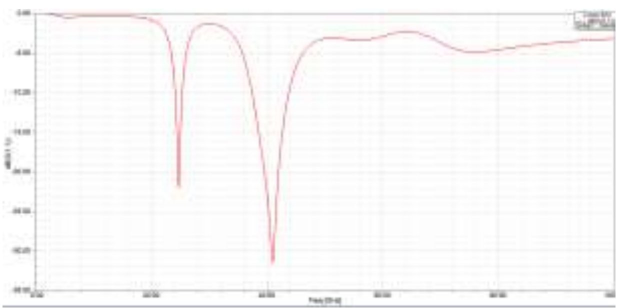

Fig2: RETURN LOSS

4.2 VSWR:

Voltagestanding wave ratio is defined as the ratio between transmitting voltage and receiving voltage in a radio frequency electrical transmission system. The VSWR value is always a positive value which tells about the performance of antenna, the smaller vswr givesbetter performance of antenna. And the proposed dual band antenna has a 1.81dB and 0.5dB VSWR value at 25GHz and 40GHz.

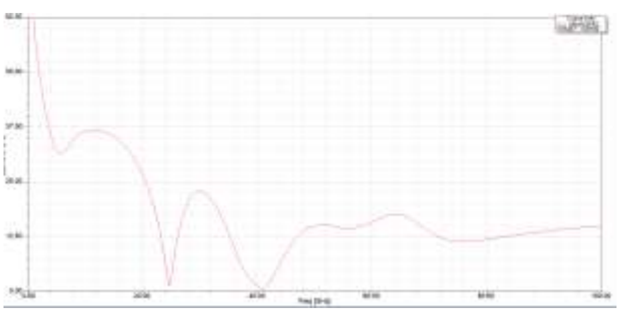

Fig3: Voltage standing wave ratio

4.3 Gain plots:

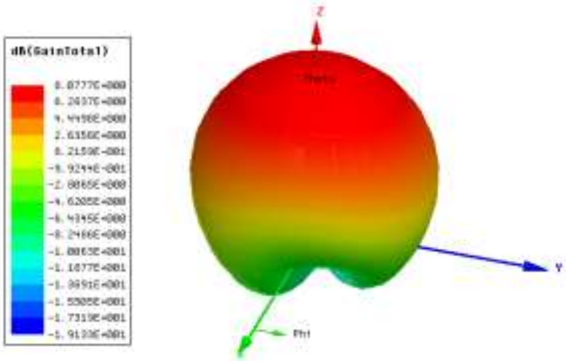

Fig4: Gain plot of antenna at a frequency of 25GHz

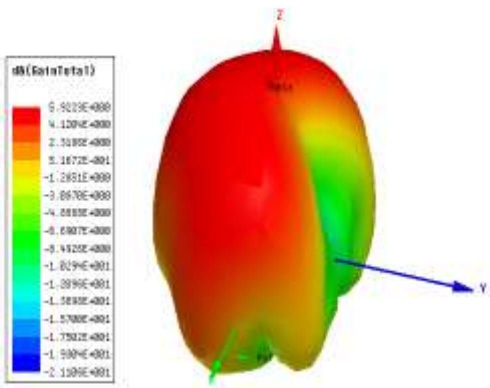

Fig5: Gain plot of antenna at a frequency of 40GHz

4.4 Directivity plots:

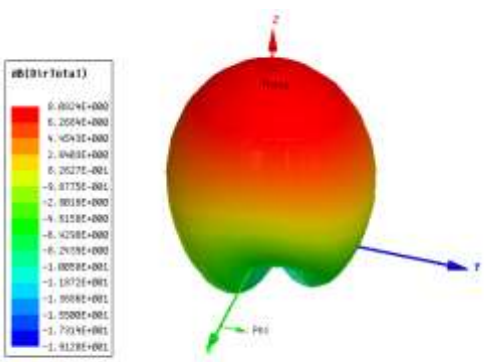

Fig6: Directivity plot of antennaat a frequency of 25GHz

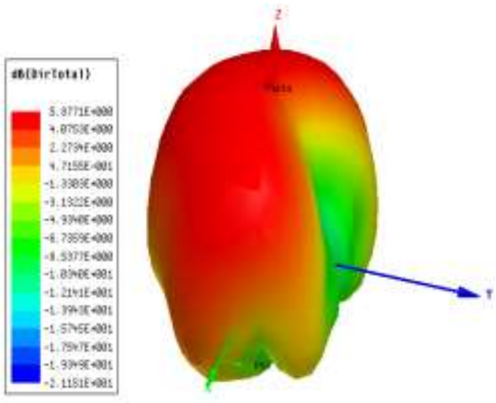

Fig7: Directivity plot of antenna at a frequency of 40GHz

4.5 Radiation patterns:

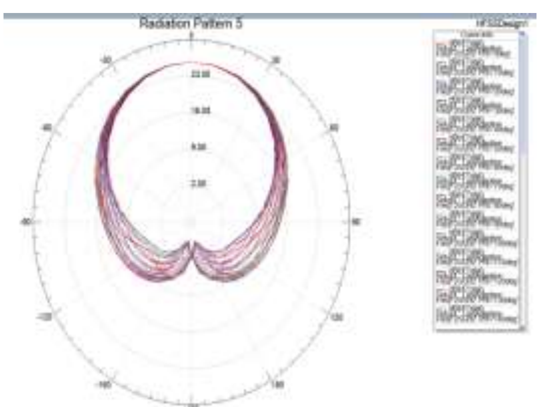

Fig8: Radiation pattern of antenna at a frequency of 25GHz

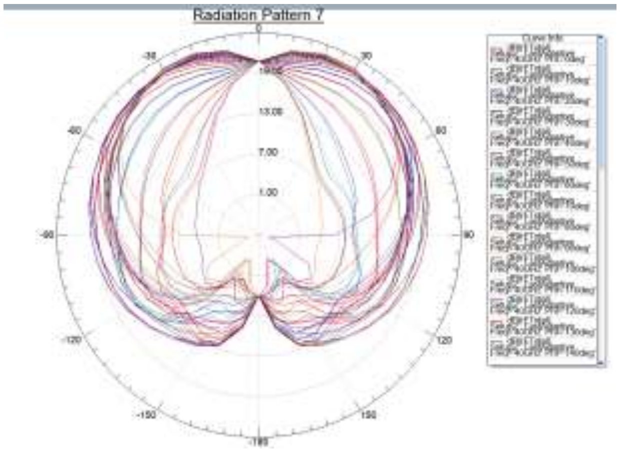

Fig9: Radiation pattern of antenna at a frequency of 40GHz

5. CONCLUSION

In this andual band U-Shaped micro strip patch antenna has been proposed for millimeter waves i.e., for wireless communication. The proposed antenna works at a frequency of 25GHz and 40GHz. The proposed antennagives a gain of 8.07dB and 5.92dB and bandwidth of 0.3GHz. This resultsthat designingof an antenna at this frequency gives the betterreturn loss , gainand bandwidth values.

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