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Research Paper

Design of a Single Band Microstrip Patch Antenna for 5G Applications

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Abstract

This article is about a single band microstrip patch antenna used for the 5G applications. And this antenna is suitable for the millimeter wave frequency. The patch antenna design consists of 2 E shaped slots and 1 H shaped slot. These slots are loaded on the radiating patch with the 50 ohms microstrip feed line. For the simulation purpose, Rogers's RT5880 dielectric substrate with relative permittivity of 2.2 and loss tangent of 0.0009 is used. The design and simulation of the antenna is done using HFSS (High Frequency Structure Simulator) software. The results are simulated for the parameters Return loss, VSWR, 3D Radiation pattern. The proposed antenna has a return loss of -42.4383 at 59 GHz millimeter wave frequency.

Keywords: *HFSS Software; Millimeter wave; Radiating patch; Return loss; Single band microstrip patch antenna.*

1. Introduction

With the advent of new wireless technologies, there is a growing need for faster communication which led to the proposal of 5G technology. 5G (Fifth Generation) has many advantages over the current generations. The main advantage is that the 5G will provide the better speeds and coverage than the 4G. And it also provides several thousands of simultaneous connections of wireless sensors [1], [2]. There are some major technological breakthroughs that will assist in the development of 5G wireless networks which includes Millimeter wave spectrum, massive MIMO, IOT, Big data and mobile cloud computing etc [3]. Among these technologies, millimeter wave frequencies have many advantages such as larger bandwidth to provide higher transmission rate, immunity to interference and simple hardware structure [4]. 5G wireless systems operate in the millimeter wave bands of 28, 38 and 60 GHz. The U.S FCC (Federal communications commission) allocated the spectrum of 57-64 GHz unlicensed band as 60 GHz ISM band which is available throughout the world [5]. WiGig (IEEE 802.11ad standard) which is the extended version of Wi-Fi provides access to the 60 GHz band. The 60 GHz band has advantages of narrow bandwidth, absorption of oxygen for better immunity towards interference, large spectral availability and highly secure [6].

In the evolution of modern wireless communications, patch antenna is a vital component. Small in size, low profile, easy manufacture and integration, low cost are the advantages of microstrip patch antenna over other antennas [7]. The proper design of microstrip antenna with correctly placed slots gives very good results in bandwidth, resonant frequency, gain, impedance, return loss etc. Feeding techniques are used to provide source to the antennas. They are Microstrip feed line technique, coaxial feed technique, aperture coupling feeding and proximity coupling technique. The selection of the feeding techniques varies depending upon its ease of fabrication, its cost, hardware implementation, impedance matching and spurious radiations caused due to the feeding technique incorporated [8]. In this design, the microstrip feed line feeding technique is used. In the proposed antenna, the E and H slots are loaded on the patch. The 50 ohms microstrip line feeding is used and the results are simulated in the HFSS software.

2. Antenna design analysis

A single band micro strip patch antenna of shape as depicted in fig.(1) is designed with the dimensions of 8mm x 8mm at 60 GHz for millimeter wave 5G applications. The main radiating element in this antenna is the patch. The slots are loaded on the patch with different dimensions. The patch is delivered by the 50 ohm microstrip line feed and the antenna is simulated on a Rogers RT5880 dielectric substrate having relative permittivity of 2.2, loss tangent of 0.0009, and height of 1.6 mm [5], [9]. HFSS software is used for simulation purpose.

The copper sheet with dimensions of 8mm x 8mm is used as the ground plane. The H and E slot cuts which are used to increase the impedance bandwidth, are made on the patch. The length of the patch is 2.9 mm and widthis3.5 mm. The length and width of the H slot is 2.2 mm and 2.5 mm. The E slots have a length and width of 1.91 mm and 1.05 mm. The microstrip feed lines have a length and width of 0.4 mm and 3.25 mm [9]. The single band antenna has been designed at the work 59 GHz millimeter wave frequency.

3. Design results and comparison

The simulation process of proposed antenna is carried out by HFSS software. Fig.(2) shows the proposed antenna structure designed in the HFSS software. The result of the parameters return loss / reflection coefficient for single band antenna is represented in fig. (3). The proposed single band antenna has the -10 dB bandwidth of the microwave frequency and cover the 60 GHz millimeter wave frequency band. These design results have a cen-

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ter frequency of 59 GHz with the bandwidth of 6.25 GHz ranging from 56 GHz to 62.25 GHz which almost covered entire 60 GHz ISM band.

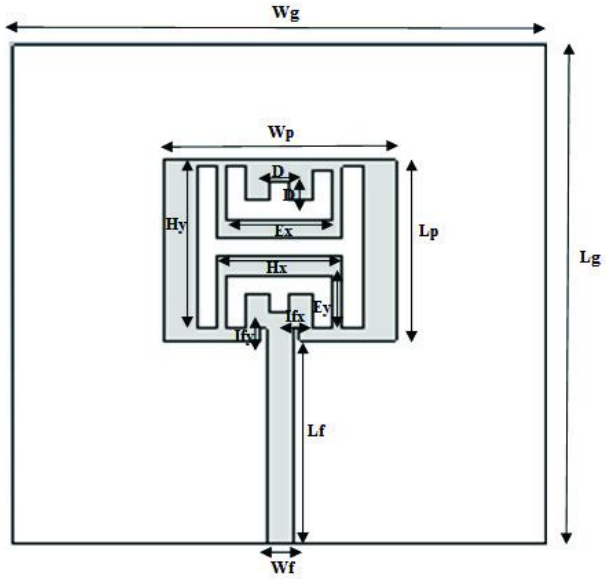


Fig. 1: Structure of proposed microstrip patch antenna

Table 1. Designed antenna dimensions

Parameters	Dimensions(mm)
W_g	8
L_g	8
W_p	3.5
L_p	2.9
W_f	0.4
L_f	3.25
If_x	0.2
If_y	0.2
H_x	2.2
H_y	2.5
E_x	1.91
E_y	1.05
D	0.3

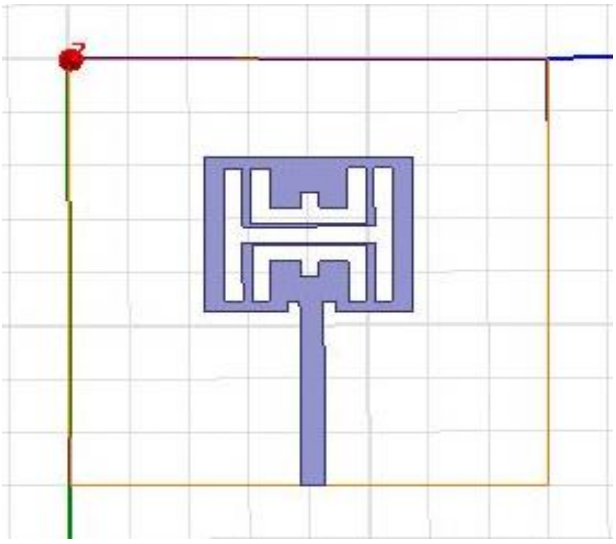


Fig. 2: Structure designed in the HFSS software

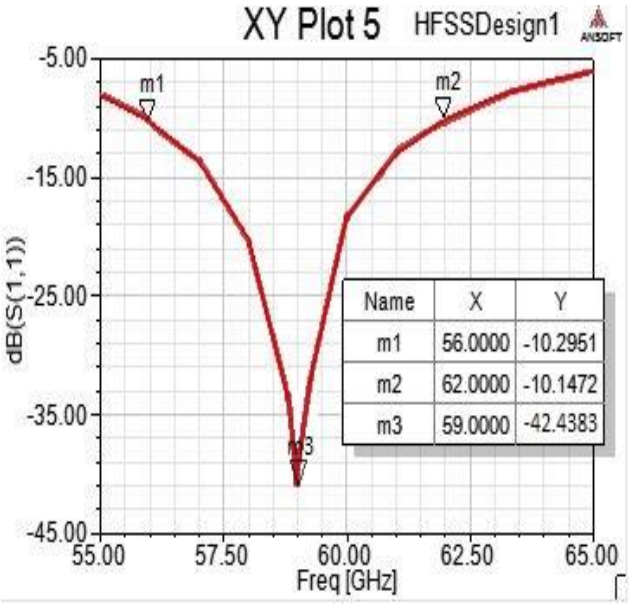


Fig. 3: Reflection coefficient S11 versus frequency of designed antenna

The VSWR plot is shown in fig.(4) at 60 GHz band which is 1.0152 approx equal to 1 representing the good impedance matching for proposed antenna [11].

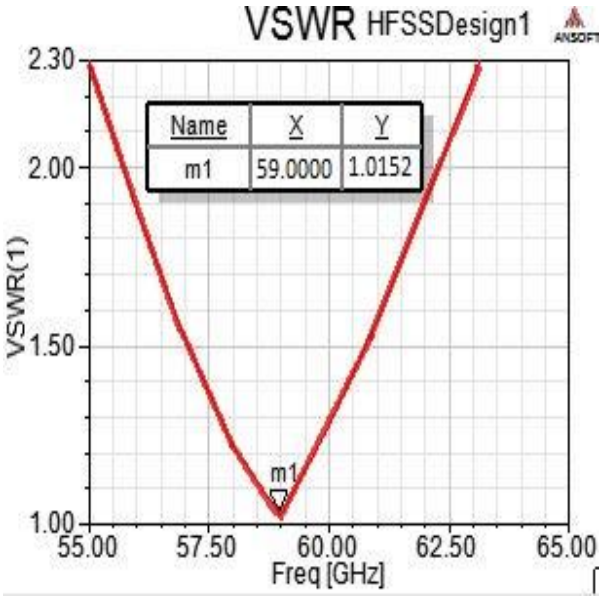


Fig. 4: VSWR curve of the designed antenna

Fig.(5) shows the 3D radiation pattern of proposed antenna and fig.(6) shows the gain of proposed antenna which is 2.0675 dB with the radiation efficiency of -1.0147 dB at 60 GHz millimeter wave frequency band [5].

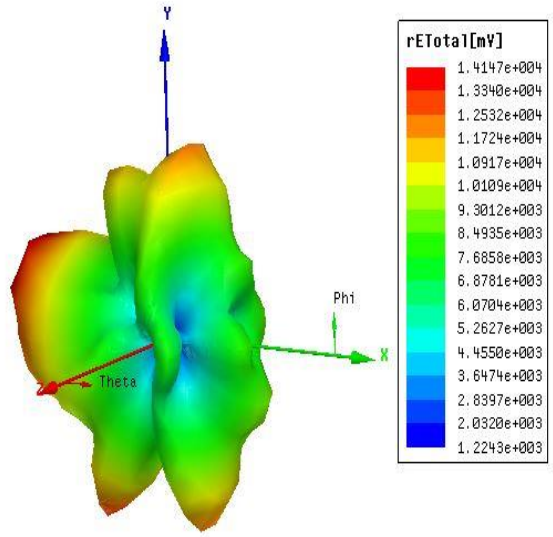


Fig. 5: 3D radiation pattern of designed antenna

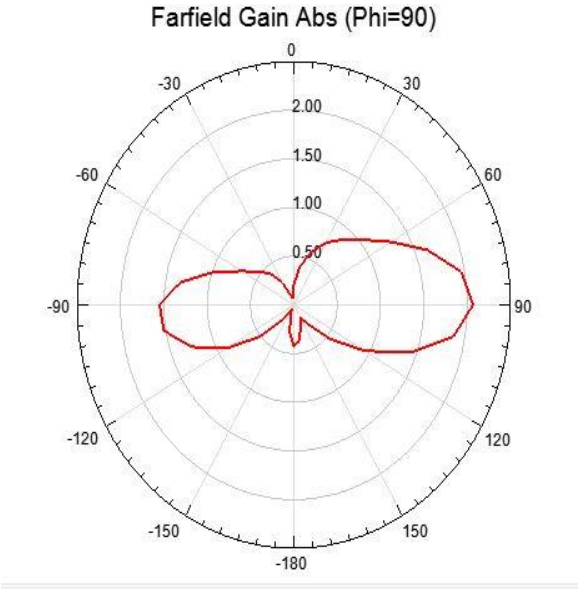


Fig. 6: Gain obtained by the antenna

Table 2. Comparison between designed antenna and Reference antenna

Parameter	Designed antenna	Reference antenna
E and H slot arm width (D)	Varied to get desired result.	0.3 mm
Return loss (s11)	-42.4383 dB	-40.99 dB
Impedance bandwidth	S11 ≤ -10 dB	S11 ≤ -10 dB
VSWR	1.0152	1.0186
Bandwidth	6.25 GHz	4.028 GHz
Centre frequency	59 GHz	59.93 GHz

Table 2 shows the comparison between the designed antenna and reference antenna. Some of the necessary changes are made in the reference antenna to get the optimized and better design using the HFSS software. The designed antenna shows the better Return loss, Gain, VSWR and Bandwidth than the reference antenna.

4. Conclusion

In this paper, the proposed antenna is of simple structure, low cost and small size. The small size of antenna operates the single band millimeter wave frequency band. Due to the H and E slots, there is an enhancement of the impedance bandwidth, gain. This simulated result shows the center frequency at 59 GHz with bandwidth of 6.25 GHz ranging from 56 GHz to 62.25 GHz with lower and higher cutoff frequencies respectively. The designed microstrip patch antennas have gain up to 2.06 dB for the millimeter wave 5G wireless application.

Due to the high directivity of the designed antenna, this can be used in defense and military applications. As the antenna is designed at millimeter wave frequency for 5G applications, it can also be changed for radar applications. The need of greater frequency spectrum for 5G applications is due to the increase in the data usage. And one of the greatest and most important uses of millimeter wave frequency band is providing larger frequency spectrum which is used in transmitting large amounts of data. Due to the high frequency of millimeter waves, they would require smaller antennas which can be achieved by grouping more antennas into devices enabling the directional transmission, i.e. the signal can actually be guided in a particular direction thus making it suitable for 5G mobile applications [10][12-21].

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