Analysis and Synthesis of Vehicular Communication, Fractal Antennas for Future Communication

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Abstract

This paper presents a micro strip fractal antenna for the applications used in lower range of 5G milli-meter wave frequencies from 25GHz to 35GHz. Fractal antenna is fed with lumped port feed structure. The stepping fed is used to provide better antenna characteristics at the said frequency range. The proposed antenna uses fractal geometry which is a self-similar in nature and can be used for wide band applications. The micro strip antenna is designed and simulated using hfss v15 with a substrate of Rogers RT duroid 5880tm with the thickness of 1.6mm and a relative permittivity of 2.2 and dielectric loss tangent of 0.0009. The size of the radiating patch is about 35mm X 40 mm and the ground plane is recessed in order to improve the total gain. The resonance frequency is set at 30 GHz such that it can be used for the lower band milli meter applications. This antenna creates the fractal geometry inside the patch with the shape of a rectangular patches at twelve different places.

Keywords: Patch Antenna, Fractal geometry, Substrate, milli-meter wave, 5G

1. INTRODUCTION

With the increase of smart phone usage, vehicular communication and various adhoc networks using the tele communication frequencies, there is a high demand of spectrum and capacity requirements [1]. To overcome these demands and provide a continuous streaming communication 5G plays an important role. The major applications are vehicular communication, mobile communication, high definition and ultra-high definition video broadcast with the minimum and maximum frequency of 25GHz ranging up to 86GHz which leads towards usage of milli meter communication[2-3]. The lower side frequencies are majorly used for the Indoor applications such as private and public personal area networks. The upper side frequencies can be used for outdoor applications as the vehicles travel at a relatively high vehicular speeds due to which the network must be a highly dynamic in nature. TO meet these requirements vehicular communication uses cellular networks. Presently the cellular networks are working hard to accommodate the network in the lower millimetre frequency range. Designing a system with the higher frequencies is very difficult and at the same time designing an antenna becomes more complex in nature [4]. The Dedicated Short-Range Communication (DSRC) service band is allotted for the V2V communication which ranges from milli meter frequency of 25GHz to 32GHz (proposed) and theses frequencies can also be used for other applications such as Vehicle to Infrastructure communication, Vehicle to user communication, vehicle to cloud communication and Vehicle to pedestrian communication [5]. To use these applications it is very important to design an antenna which should have a high gain at the same point should be a multi band application system [6-7]. A micro strip patch antenna alone cannot serve the required need, instead a multi array antenna can be used, but the drawback is the limitations over the size and place occupied by the antenna and the difficulty of multi array antenna is its impossible conformal antenna structure [8]. As the advancements towards implementing fractal geometry on a patch makes the antenna a multi band and at the same time can be designed to be a conformal in nature with not compromising on the occupancy of the structure [9]. As the literature survey conducted on the various designs and aspects, antenna is the key feature of any system as it enhances the integration of various frequency based applications. This paper compiles of usage of fractal geometry and to enhance the structure to achieve all the required parameters [10]. The most interesting information regarding the fractal geometry is that structure of the antenna remains same but number of iterations can be increased such that a single antenna can acts as a multi array antenna, and the performance is better than the physical array structured antenna [11-14]. So many structured fractal geometry with different shapes were implemented for the frequencies ranging a maximum of 5GHz, as the wireless communication band falls in this range [15]. The present scenario is different and fast accessing higher frequencies and milli meter communication. Various designs consisting of Sierpinski gasket, Koch curves, Hilbert curve and fractal tree are introduced as fractal shapes on the patch [16-20]. We used a rectangular patch as a fractal geometry for our design. Recessed ground is used to enhance the features of the antenna with increased in gain and directivity.

Introduction of these fractal shape patch antenna enhances multi band applications, reduction of distortion, self-scalable and relatively low side lobes with time harmonic and time dependent radiation. The length of the patch usually ranges between $0.3333\lambda o<L<0.5\lambda o$, where λo is the free-space wavelength . The height h of the dielectric substrate is in the range of $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$. The dielectric constant of the substrate (ϵr) ranges $2.2 \leq \epsilon r \leq 12$.These ranges are even applicable for the fractal geometry based antennas. Fractal antennas have nature inspired structures resulting in highly convoluted shapes. Most important advantages are to reduce the overall size of the antenna and to induce multiple resonant mods. The proposed prototype is designed using polymer-based flexible substrate Roger RT/duroid 5880 with the thickness of 1.6mm. The conductive parts of a proposed antenna are etched on copper cladding with an expected conductivity of 5.96x107S/m and thickness of 35µm. The Rogers substrate has an estimated dielectric constant of 2.20 and a tangent loss of 9x10-4 at operational frequency band. Design of the antenna is discussed in section II. Section III is described the simulation results of the proposed antenna following with conclusion in section IV.

2. Antenna Design

In this section we will discuss about the design of the fractal antenna for the frequencies ranging from 25GHz to 35 GHz with the resonating frequency of 30GHz.With design principles rectangular geometry is used to design the patch with length Lp and width Wp with the dimensions of 35mm x 40mm. The novel patch is printed on the Rogers RT 5880 lossy substrate. The dielectric constant and the loss tangent of the substrate are 2.2 and 0.0009. The height of the substrate material (*hs*) 1.6mm and the size of the substrate is 72mm x 60 mm. The ground is recessed and the average area covered is around 75% of the total substrate. A triangular shaped portions are etched at different places to satisfy the circular polarization property and each etched out place is replaced with a basic rectangular patch shape design to satisfy the fractal geometry concept. Each basic patch consist of dimension of 1 X 2 mm rectangular shape within the etched triangles. In the design 12 triangles are etched and rectangular patch are placed.

Description	Dimensions
Substrate	72 X 60 X 1.6
Patch (A_{conv})	35 X 40
Ground	72 X 60
Inner Triangle(A_{tri})	2 X 2 X 2
Inner Patch (A_{patch})	1 X 2
Number of triangles	12

Table 1.Dimensions of the antenna

The total fractal area is compounded using the equation

$A_{total}= A_{conv} -(12 \times A_{tri}) + (12 \times A_{patch})$……………………………….1

Hence, the computed total fractal area of the proposed radiating geometry is of 25.9 cm2 which has been obtained from the equation.

The figure 1 shows the patch design of the antenna which consist of 12 triangles etched away and introduced a rectangular patch in it.

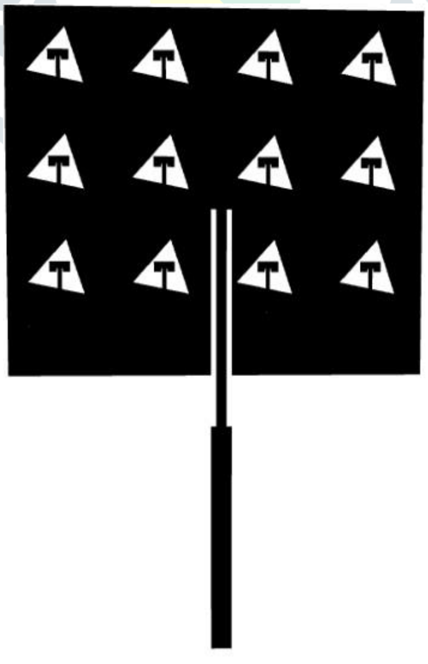

Fig1: Micro strip Patch antenna with Fractal geometry

The proposed antenna is itself the state of the art design which can be used for the higher frequencies, where there are 12 nano patch antennas which can be seen in figure 1. These nano patches can work as 12 different antennas with that same dimensions act as an array.

The ground is a recessed ground which is in contrast with the design of the patch. The triangles which are etched on the patch, similar way the ground is etched using circular in shape and to provide the ground to the nano patch, nano rectangles are added as shown in the figure 2.

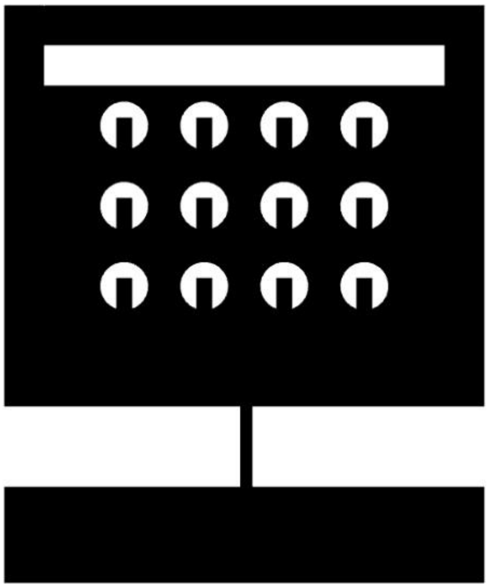

Fig 2: Recessed Ground using unorthodox design

3. Simulation Results

Let us discuss now the simulation results of the antenna at the frequencies ranging from 25GHz to 35GHz with the resonance at 30GHz. The results are obtained in three different categories, consisting of return loss (S11), VSWR and Total Gain. The results are achieved using the simulation done in HFSS v 15. Let us discuss first about the return losses which are scaled using the rectangular plot with less than -10dB. The following figure 3 shows the return losses of the antenna.

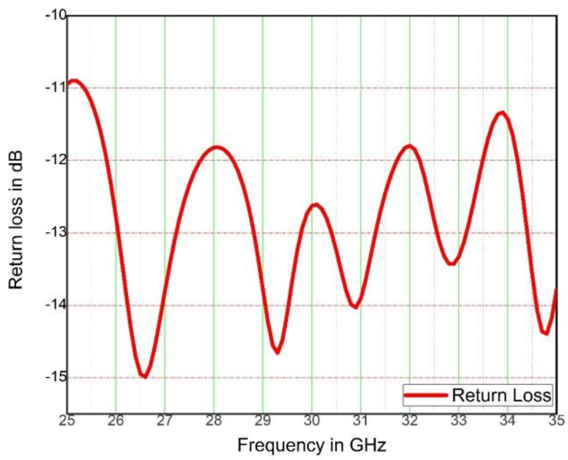

Figure 3: Return losses of the antenna for frequency ranges from 25GHz to 35GHz.

The minimum return losses of the antenna is measured at -15db and for the entire range the return losses are less than -10db. The bandwidth can be calculated using the return losses where the entire range can be considered and let us now move on towards the VSWR which is also measured using rectangular plot with less than 2dB values are considered to be a good feature of the antenna.

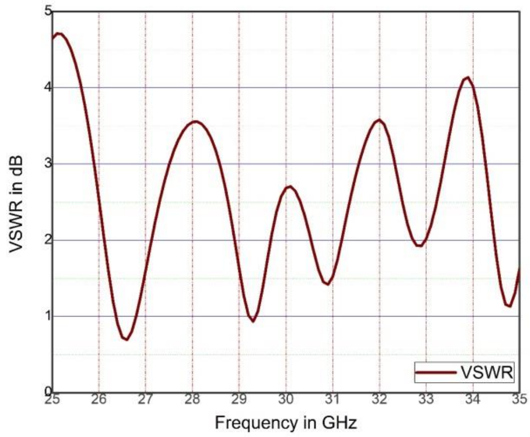

Figure 4: VSWR of the antenna for the frequencies 25GHz to 35GHz.

Gain is achieved in many ways, most commonly real gain but the most appropriate gain can be calculated using phi and theta to be at zero degrees.

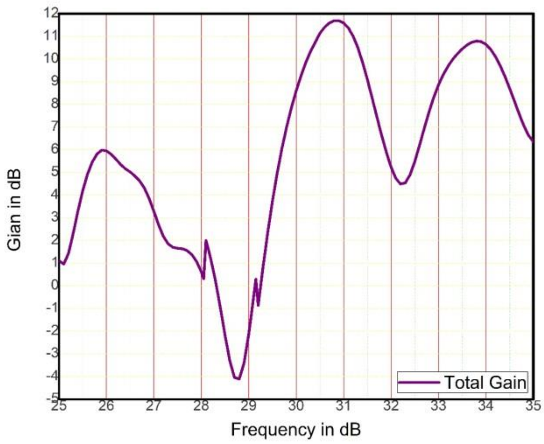

Fig 5: Total Gain achieved by the antenna at the frequency 25GHz to 35GHz.

The maximum gain achieved is around 11dB and to calculate the bandwidth of the antenna, 3dB or more than 3dB values are considered.

S.No	Frequency(GHz)	Minimum Return Loss(dB)	Minimum VSWR(dB)	Maximum Total Gain(dB)	Bandwidth(MHz)
1	26.15-27	-14.9915	0.70890051	5.698	850
2	29.45-29.65	-14.2927	1.213344448	5.511	200
3	30.55-31.15	-14.0308	1.418959187	11.697	600
4	32.75-32.95	-13.4295	1.972126574	8.584	200
5	34.5-35	-14.3948	1.132526132	8.712	500

Table2. Bandwidth for the proposed antenna

The bandwidth is calculated using the concept of total gain equal or greater than 3dB, VSWR less than or equal to 2dB and return losses less than -10dB. The range is provided in the table 2 where for the entire range of frequencies, the bandwidth achieved is 2350MHz in the entire range and the highest is around 800MHz for thr range of 26.15GHz to 27GHz and 600MHz at the range of 30.55GHz to 31.15GHz and 500MHz at 34.5GHz to 35GHz. These three ranges are the best ranges for the antenna to provide better performance. These range of frequencies can be used for various multiple applications.

4. Conclusion

This paper presented the simulation of a micro strip patch antenna using fractal geometry at the frequencies ranging from 25GHz to 35GHz. Return losses, VSWR and Total gain were achieved using simulation in HFSS v15, with the substrate as Rogers RT duroid 5880tm and the thickness of 1.6mm. The results were very much satisfactory and can be used for various applications both indoor as well as outdoor. As per the simulation results, the highest gain achieved is around 11.67dB and the lowest return losses as -15dB. The antenna achieved a total bandwidth of 2.35GHz in the said frequency ranges. The maximum Bandwidth for resonating frequencies are 850MHz, 600MHz, 500MHz and 200MHz. The proposed antenna can be used as a multi band application antenna as we can observe that there are multiple resonating points with goo bandwidth. The future scope for this antenna is to design using multiple fractal iterations and different shapes for achieving greater bandwidths and further reduction in return losses.

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