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Multi Band Minswoki Fractal Antenna for 5G Applications.

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Abstract: Forthcoming 5G wireless communication network will be combined version of all the wireless and wired networks including K-Band and Ka-Band. Presently in 4G wireless network, numbers of researchers have found different antennas which can combine maximum of four frequencies. This proposed antenna will work for at seven combined wireless 5G applications. The Proposed Multi Band Minswoki Fractal Antenna for 5G work for several services such as k-Band and Ka-Band(18Ghz-26.5Ghz and 26.5Ghz-40Ghz) application. The proposed prototype is extremely reduced in size having the dimensions 18×25 mm and is enhanced to be worked in the band from 20 to 50GHz.The antenna consists of a Fractal Shaped rectangular patch with micro strip line feed etched on FR4-Epoxy substrate with height 1.6 mm. The antenna has designed and optimized on High Frequency Structure Simulator (HFSS).

Keywords: S11, VSWR, 3D-Gain, Directivity and Radiation Pattern.

I. INTRODUCTION

5G frameworks will have a lot more prominent data transmission than the current correspondence framework. Future broad band mobile communication networks such as 5G and beyond will most likely use millimetre-wave frequencies.5G will use spectrum in the existing LTE frequency range(600MHZ-6GHZ) and also in millimeter wave band(24GHZ-86GHZ).

A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale. A fractal antenna is created using the fractal geometry. The inherent qualities of fractals enable the production of high performance antennas that are typically 50 to 75 percent smaller than traditional antennas. Fractal antennas are also reliable and cost-effective.

The geometry of the fractal antenna encourages its study both as a multiband solution and also as a small (physical size) antenna. First, because one should expect a self similar antenna (which contains many copies of itself at several scales) to operate in a similar way at several wavelengths. That is, the antenna should keep similar radiation parameters through several bands. Second, because the space-filling properties of some fractal shapes (the fractal dimension) might allow fractal shaped small antennas to better take advantage of the small surrounding space.

Fractal antennas have greater bandwidth compared to conventional antennas. By using fractal antennas several resonant frequencies can be achieved. Miniaturization of antenna occurs due to self-similarity, self scaling and space-filling properties of fractal geometry.

In this sense, the application of fractal geometry in the design of antennas and antenna arrays can help in dealing with the problems of designing antennas that meet the requirements of modern communication systems not found so far.

TYPES OF FRACTAL GEOMETRY[1]:

1.Sierpinski Gasket:

The shape is attained by extracting the central part of main triangle with inverted equilateral triangle from the main triangle and this process can be repeated to attain the desired geometry.

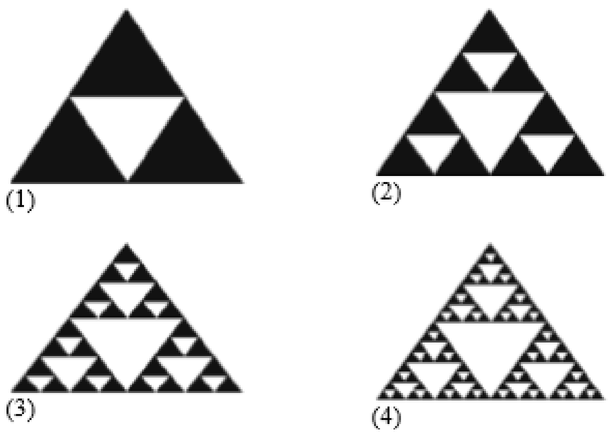

Fig1: Sierpinski Gasket

2. Koch curve:

Koch curve is the simplest fractal. It is generated by dividing the straight line into three parts. The middle part of the straight line bends into the triangular shape as shown in Koch curve with flare angle 60 as indicated in fig b.

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The same process can be repeated for the fractal geometry up to finite number of iterations.

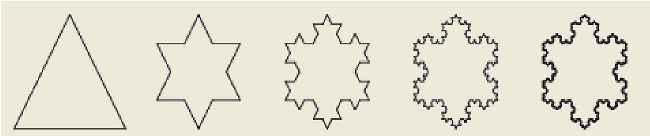


Fig 2 :Koch curve

3. Hilbert curve:

These curve consist of various stages where each following stage contains four copies of the previous one, along with one extra line segment.

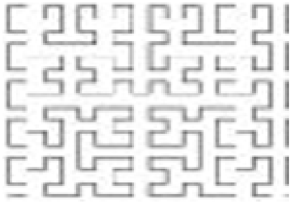
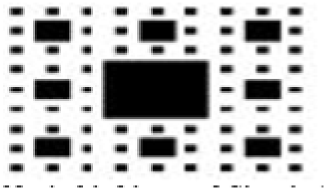


Fig 3:Hilbert curve

4. Sierpinski Carpet:

The Sierpinski Carpet geometry is obtained by using the rectangular patch.The rectangle of one-third size is subtracted from the centre of the main rectangle and this process is repeated number of times to attain the desired geometry.



5. Minswoki:

The Minkowski fractal is formed by displacing the middle one-third of each straight segment (indentation length) by some fraction called the indentation width. Indentation factor (i) is defined here as the ratio of indentation width to the indentation length.

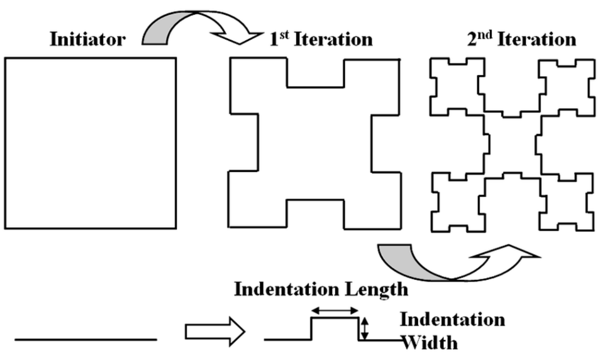


Fig 5: Iterative generation Procedure for a Minkowski Fractal

The Proposed Multi Band Minswoki Fractal Antenna for 5G application has numerous advantages like Miniaturization

- ➨Better matching of input impedance
- ➨One antenna is sufficient to take care of multiple bands both narrowband and wideband.
- ➨It provides consistent performance over huge frequency range. Hence fractal antenna is considered to be frequency independent.
- ➨There will be reduced mutual coupling in array antennas made using fractal geometrical approach compared to conventional Micro Strip Antennas and other types of Fractal geometries. The Proposed antenna enhances the range from UWB frequency to millimeter frequency covers the band from 20 Ghz to 50 Ghz and it has numerous applications like k-Band and Ka-Band(18Ghz-26.5Ghz and 26.5Ghz-40Ghz).

II. ANTENNA DESIGN

The Minkowski fractal geometry uses a generation curve as the basic structure and it is named according to the mathematician H.Minkowski. Minswoki fractal antenna is constructed by taking four line segments in the form of square and 1/3rd of each line segment is replaced with generator curve and if no of iterations increases miniaturization of antenna can be obtained.

The proposed Minswoki fractal patch antenna with square patch element has been designed[3]. As the length and width of base shape (zero order) plays a salient role in determining the resonant frequency, we have specifically defined the geometry from zero to second order. The base shape is also called initiator which is shown in figure 6..

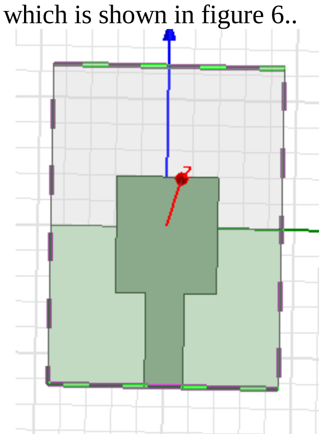


Fig 6: Zeroth Iteration

The first order design is being formed from first iteration by removal of rectangular cuts from each ine segment of the proposed base shape. The first order shape of this antenna has been shown in figure 7.

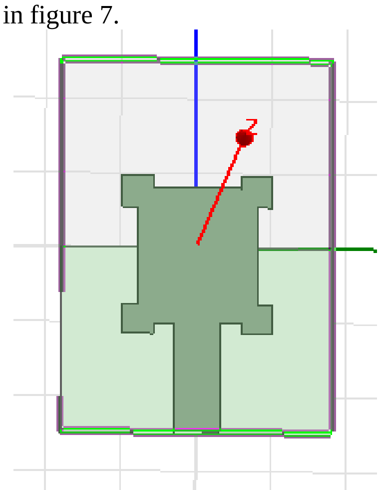


Fig 7: First Iteration

In second order, the same process is repeated and rectangular cuts are being cut or iterated from each line segment of the proposed first order shape.

The second order shape of this antenna has been shown in figure 8.

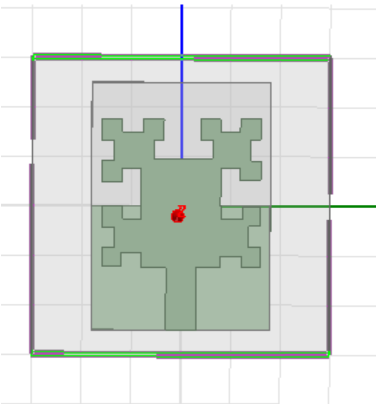


Fig 8: Second Iteration of Proposed Antenna

Proposed antenna is recreated and enhanced utilizing Hfss software. RO 4232 having dielectric steady 3.2, misfortune digression 0.0018 and height 1.520mm is utilized to recreate the structure. By and large elements of the antenna WXL are 18mm×25mm and partial ground id used.

Table- I: Dimensions of Proposed Antenna

Parameter	Value(mm)
a	9.3
s	0.48
l	25
w	18
Ls	8.8
Ws	3
Lg	11
Wg	15.9

III. ANTENNA PARAMETERS

Return loss (s11):

The **definition** of **return loss** is that it is the **loss** of power in the signal **returned** / reflected by a discontinuity in a transmission line or optical fibre.

- Return loss also known as Reflection Coefficient.
- It is measured in db.

VSWR (Voltage Standing Wave Ratio):

- It defines how much power is transferred or delivered from source to load through the transmission line.
- The ideal value of VSWR is between 1 to 2.

Table- III: VSWR values of Base shape

Bandwidth: The difference between higher frequency and lower frequency on -10db line over the particular range.

Gain:

Vswr(db)	Freq(GHZ)
1.02	29.6
1.5	33.3
1.9	45.68

Antenna gain classified into 3 types:

- Transmitting Antenna: Ability of antenna to radiate more in a preferred direction and suppress the radiation in other direction.
- Receiving Antenna: Ability of antenna to receive more from preferred direction.
- Directive gain:

  The **Directive Gain** (D_G) is defined as the ratio of radiation intensity due to the test **antenna** to isotropic **antenna** (hypothetical **antenna** that radiates uniformly in all direction).

Directivity: Maximum directive gain is known as Directivity

IV. RESULTS AND DISCUSSION

The proposed antenna configuration has been recreated for the recurrence run from 20GHz to 50GHz.

For Zeroth Iteration the resonant frequencies are

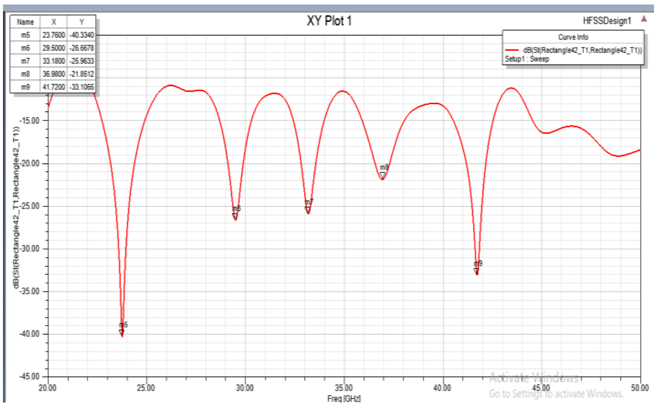


Fig 9. Return Loss for Base shape.

Table- II: Return Loss values of Base shape

S11(db)	Freq(GHZ)
-39.7,	24.9
-24.6	29.6
-20.81	33.3
-41.59	37.48
-35.68	41.95
-19.13	45.68

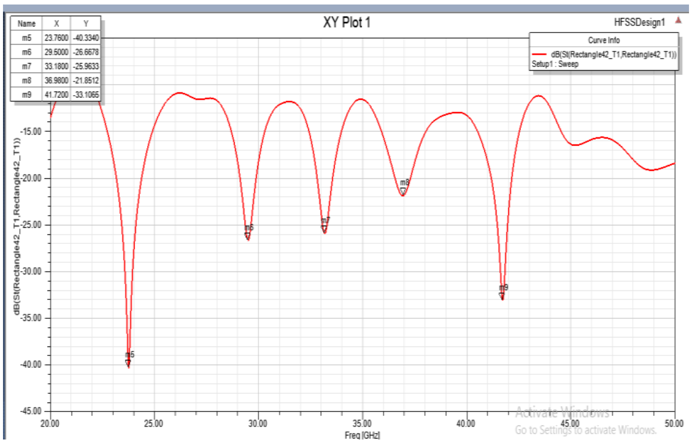


Fig 10. VSWR for Base shape.

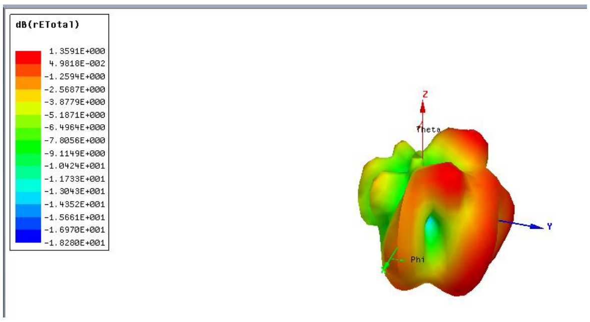


Fig 11. 3D Radiation Pattern for Base shape.

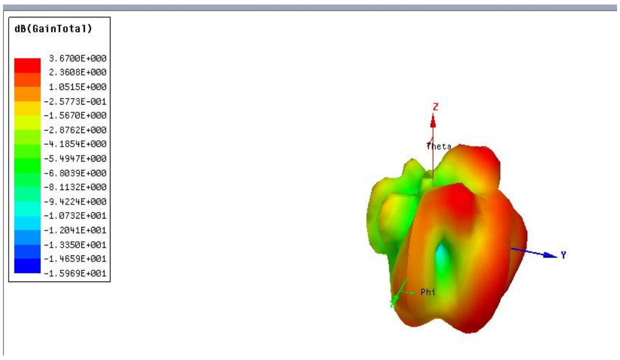


Fig 12. 3D gain for Base shape.

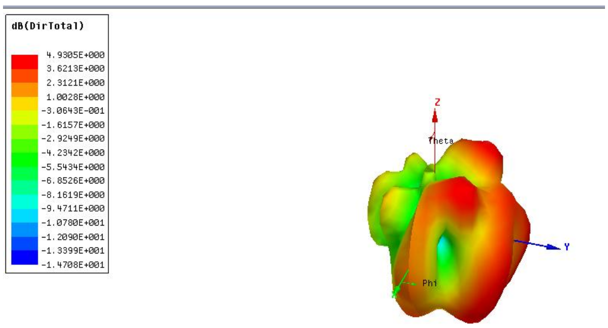


Fig 13. 3D Directivity for Base shape

Table- IV: Gain, Directivity, Radiation Pattern of Base Shape

PARAMETER	VALUE
GAIN	3.55
DIRECTIVITY	4.9
RADIATION PATTERN	1.01

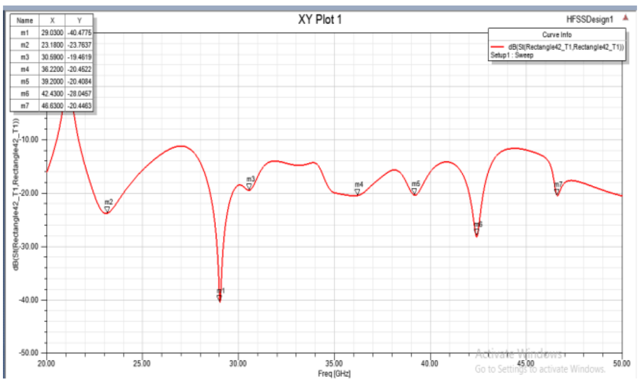


Fig 14. Return Loss for 1st Iteration

Table- V: Return Loss values of 1st Iteration shape

S11(db)	Freq (GHZ)
-40.4	29.03
-23.7	23.14
-19.4	30.5
-20.45	36.22
-20.4	39.2
-28.04	42.43
-20.44	46.63

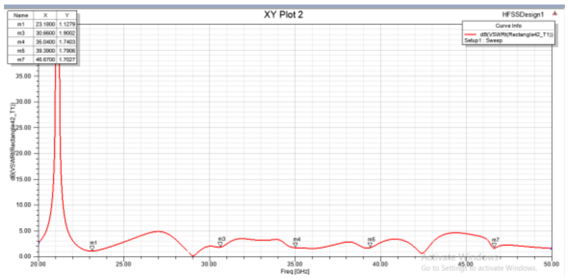


Fig 15 : VSWR for 1st Iteration

Table- VI: VSWR values of 1st Iteration

Vswr(db)	Freq(GHZ)
1.12	23.18
1.9	30.5
1.74	36.22
1.79	39.2
1.7	46.63

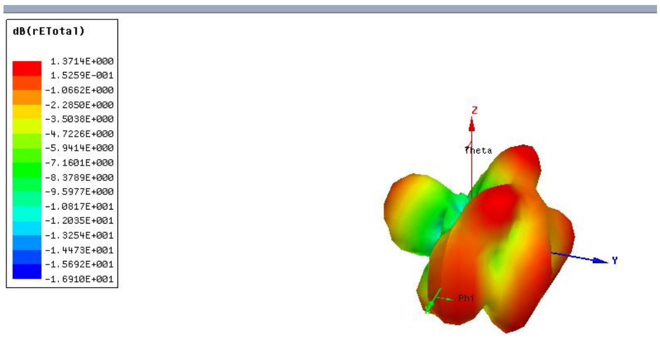


Fig 16. 3D Radiation Pattern for 1st Iteration.

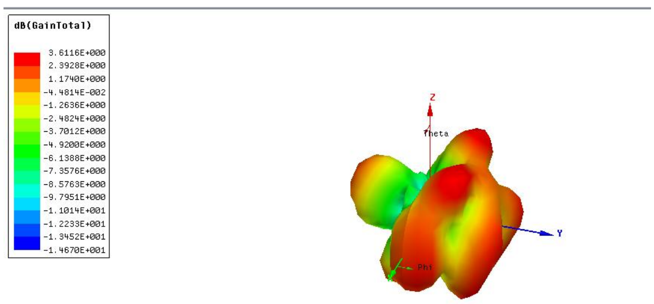


Fig 17. 3D gain for 1st Iteration

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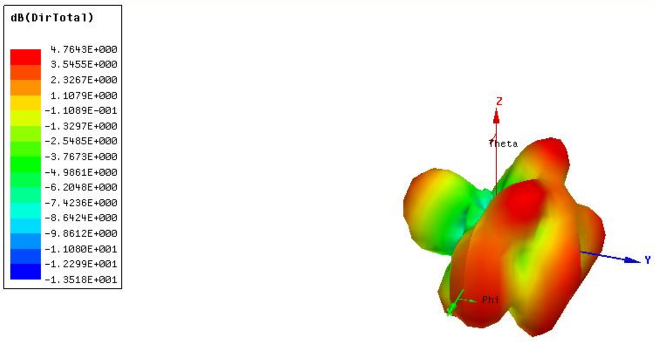

Fig 18. 3D Directivity for 1st Iteration.

Table- VII: Gain, Directivity, Radiation Pattern of 1st Iteration Shape

PARAMETER	VALUE
GAIN	3.63
DIRECTIVITY	4.7
RADIATION PATTERN	1.39

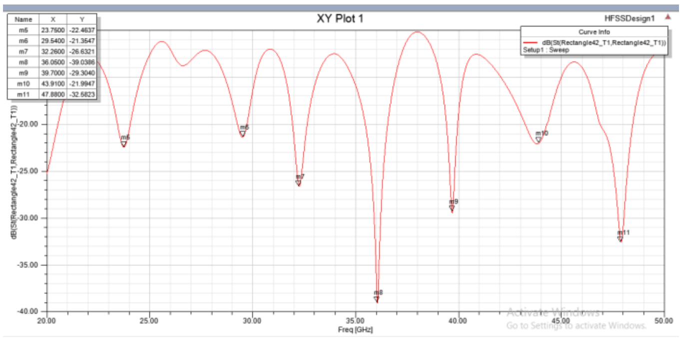

Fig 19: Return Loss for 2nd Iteration.

Table VIII: Return Loss for 2nd Iteration (Proposed Antenna)

S11(db)	Freq(GHZ)
-22.4	23.75
-21.35	29.5
-39	36
-29.3	39.7
-21.9	43.9
-32.5	47.8
26.6	32.26

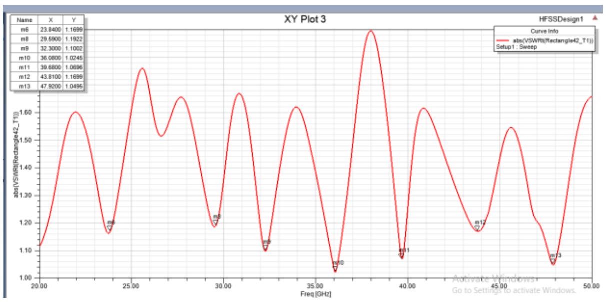

Fig 20: VSWR for 2nd Iteration.

Table IX : VSWR for 2nd Iteration.

Vswr(db)	Freq(GHZ)
1.16	23.75
1.19	29.5
1.1	32.26
1	36
1.06	39.7
1.1	43.9
1.04	47.8

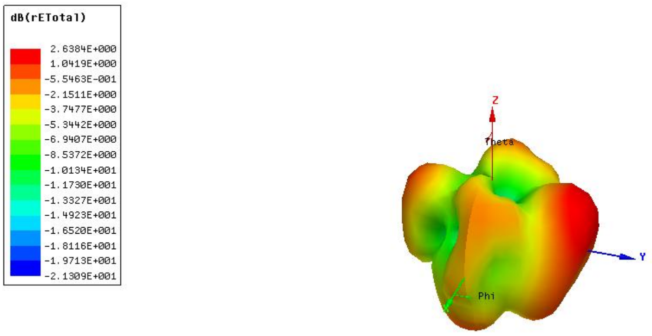

Fig 21. 3D Radiation Pattern for 2nd Iteration.

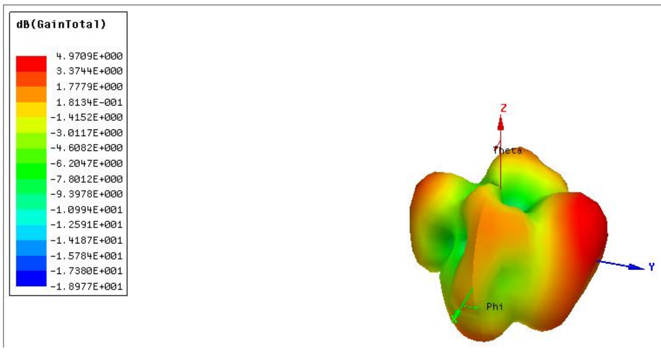

Fig 22. 3D gain for 2nd Iteration.

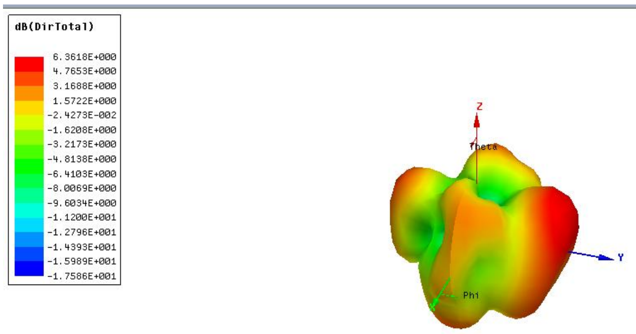

Fig 23: 3D Directivity for 2nd Iteration

Table X : Gain, Directivity, Radiation Pattern of 2nd Iteration Shape

Parameter	2nd Iteration
Gain	4.9
Directivity	6.3
Radiation Pattern	2.6

Table XI : Comparative Performance between Gain, Directivity, Radiation Pattern of 0th, 1st , 2nd Iteration Shapes

Parameter	0th Iteration	1st Iteration	2nd Iteration
Gain	3.55	3.63	4.9
Directivity	4.95	4.7	6.3
Radiation Pattern	1.01	1.39	2.6

Table XII: Comparative Performance between S11 and VSWR of 0th Iteration

S11(db)	Freq (GHZ)	Vswr(db)	Freq(GHZ)
		1.12	23.18
-40.4	29.03	1.9	30.5
-23.7	23.14	1.74	36.22
-19.4	30.5	1.79	39.2
-20.45	36.22	1.7	46.63
-20.4	39.2		
-28.04	42.43		
-20.44	46.63		

Table XIII: Comparative Performance between S11 and VSWR of 1st Iteration.

S11(db)	Freq(GHZ)	Vswr(db)	Freq(GHZ)
-22.4	23.75	1.16	23.75
-21.35	29.5	1.19	29.5
-39	36	1.1	32.26
-29.3	39.7	1	36
-21.9	43.9	1.06	39.7
-32.5	47.8	1.1	43.9
26.6	32.26	1.04	47.8

Table XIV: Comparative Performance between S11 and VSWR of 2nd Iteration.

S11(db)	Freq GHZ	Vswr(db)	Freq(GHZ)
-39.7,	24.9	1.02	29.6
-24.6	29.6	1.5	33.3
-20.81	33.3	1.9	45.68
-41.59	37.48		
-35.68	41.95		
-19.13	45.68		

IV. CONCLUSION

A fractal antenna of dimensions 18X25X1.6 is designed with a fractal structure. The band of frequencies runs from 20GHz to 50GHz. The substrate used for this prototype is FR4 Eproxy with a 3.2, loss tangent of 0.0018 and a thickness of 1.6mm. The gain has enhanced upto 4.9dB and the return losses are less than -10dB throughout the band. While increasing no of Iterations gain and radiation pattern increases. Three Iterations of designs are proposed out of which the third iteration is the best one. The designing is done using the high frequency simulation software and the results are observed**.** The Proposed antenna is widely used in satellite communications, astronomical observations and radars. Radar in this frequency range provide short range and high resolution.

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3. Design of Multi standard Fractal and Planar Antennas in MIMO Configuration for Handheld Terminal Applications.

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Kolli Venkatroa, working as an assistant professor in the stream of ECE in SRKR engineering college, Bhimavaram, India. His area of interest is microstrip patch antennas. Published few papers on this area. Currently his research was going on microstrip antennas for 5G applications.

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