

Stacked Fractal Antenna Having Multiband With High Bandwidth

Nikhil Kumar Gupta¹

*Electronics & communication, Bharati Vidyapeeth's College of Engineering, A-4 Paschim Vihar
New Delhi, Delhi, 110063, India*

Sahil Bhasin²

*Electronics & communication, Bharati Vidyapeeth's College of Engineering, A-4 Paschim Vihar
New Delhi, Delhi, 110063, India*

Varun Pahuja³

*Electronics & communication, Bharati Vidyapeeth's College of Engineering, A-4 Paschim Vihar
New Delhi, Delhi, 110063, India*

Abstract

This paper aims to optimize the multiband performance of a patch fractal antenna by varying the number of iterations of the Sierpinski's carpet fractal and increasing number of layers of the patch. In this paper a Sierpinski's carpet microstrip fractal antenna with three levels of iteration having multiband in the C band has been designed. We got four bands at the resonance frequencies - 5.2GHz, 5.5GHz, 6.8GHz, 7.1GHz having wide bandwidth which can be used for high speed multiband applications.

Keywords— Fractals, stacking, multiband, patch antenna

1. Introduction

The wireless industry is witnessing a volatile emergence today in present era. Today's antenna systems demand versatility and unobtrusiveness. Some application are looking for systems that works on several frequency bands[5]. Some applications require the antenna to be as miniaturized as possible. Fractal plays a prominent role for these requirements. Fractals have the property of non-integral dimensions and space filling capability which could be used for miniaturising the antenna size and their property of being self-similar in the geometry is used in antennas which require a large number of resonant frequencies. Fractal antennas also have multiband performance at non-harmonic frequencies. Fractal antennas have improved impedance, improved SWR(standing wave ratio) performance on a reduced physical area when compared to non fractal Euclidean geometries.

Fractal antennas show compressed resonant behaviour. At higher frequencies the fractal antennas are naturally broadband. Polarization and phasing of fractal antenna is possible. In many cases, the use of fractal element antennas can simplify circuit design.

The geometry of fractals is important because the effective length of the fractal antennas can be increased while keeping the total area same [1]. The shape of the fractal antenna can be formed by an iterative mathematical process, called Iterative Function Systems (IFS)[1]. IFS represent an extremely versatile method for conveniently generating a wide variety of useful fractal structures. Fractal geometries have found intricate place in science as a representation of some of the unique geometrical features occurring in nature[2]. A fractal element antenna, or FEA, is one that has been shaped in a fractal fashion, either through bending or shaping a volume, or introducing holes. They are based on fractal shapes such as the Sierpinski triangle, Mandelbrot tree, Koch curve, and Koch Island. In order for an antenna to work equally well at all frequencies, it must satisfy two criteria: it must be symmetrical about a point, and it must be self-similar, having the same basic appearance at every scale: that is, it has to be a fractal [2].

The application of fractal geometry to conventional patch antenna structures modifies the shape of the antennas in order to increase its effective electrical length at the same time reducing their overall

geometrical size. Because fractal geometries have two main features in common, space-filling and self-similar properties, fractal shape antenna elements present various advantages like wide bandwidth, multiband and reduced antenna size, among others[4]. Sierpinski fractal geometry exhibits well-known features that have been used to construct miniaturized radiating patches which may be either monopole or dipole antennas. By applying the Sierpinski fractal shape to the antennas, the overall electrical length of the antennas increases and the resonance frequency becomes lower than that of conventional monopole, loop, and patch-type antenna [3].

In the present work, Sierpinski Gasket fractal geometry has been applied to a rectangular microstrip patch antenna to reduce its overall size, and the effectiveness of this technique is verified through experimental investigations. Microstrip patch antennas employing Sierpinski Gasket fractal geometry can operate at a much lower frequency range while maintaining an identical overall antenna size. An electromagnetic coupled stacked structure to operate at different frequencies has been designed for multiband WLAN applications.

2. Proposed Fractal Geometry

The fractal antenna has been designed and simulated using IE3d by Zeland. The specifications of the antenna are as follows:

Patch Length- 27mm

Patch Width- 39mm

Thickness of patch- 1.58mm

Dielectric constant- 4.4

The following are the simulation results of the sierpinski carpet fractal antenna.

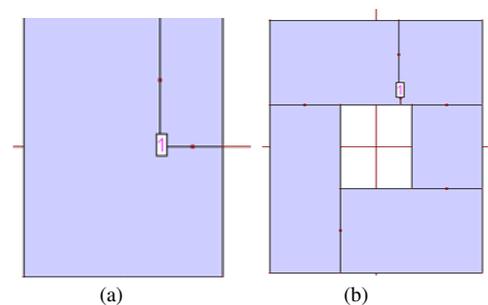
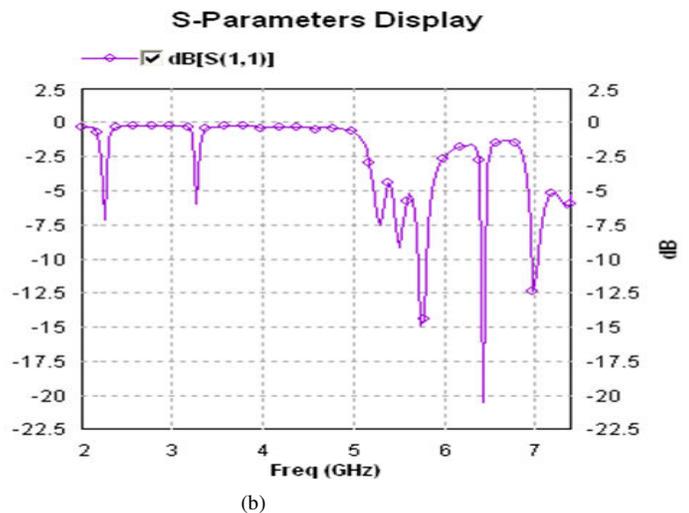
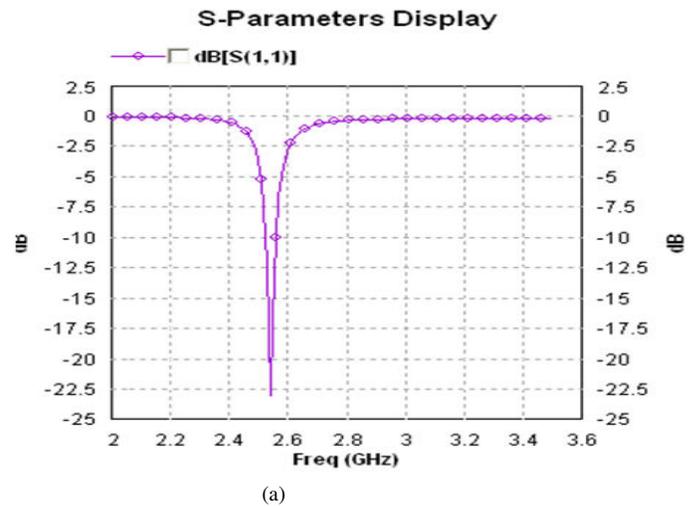


Fig 1 Different iterations of fractal antenna used
(a)Zeroth iteration (b)First iteration (c)Second Iteration

3. Simulation Results Of Single Layer Fractal Antenna

3.1. S-Parameter



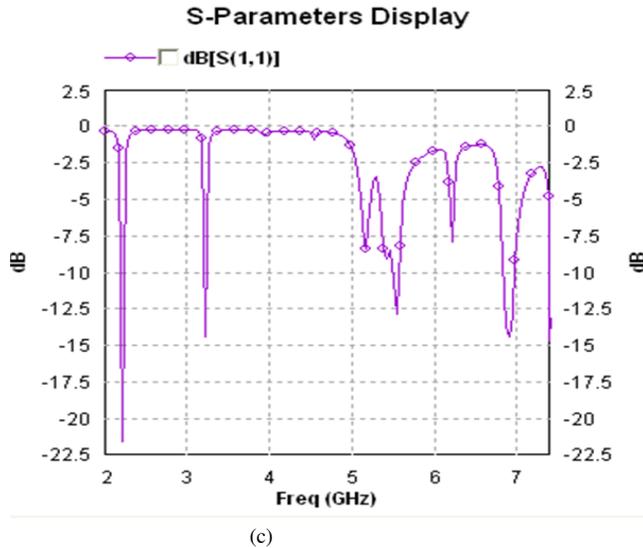


Fig 2. Return loss vs. frequency
 (a)Zeroth iteration (b)First iteration (c)Second iteration

From above graph we find as iteration of fractal increases, we get more number of bands with different frequencies.

3.2. Total Field Gain

The following graphs give a comparison of maximum gain of the antenna at different

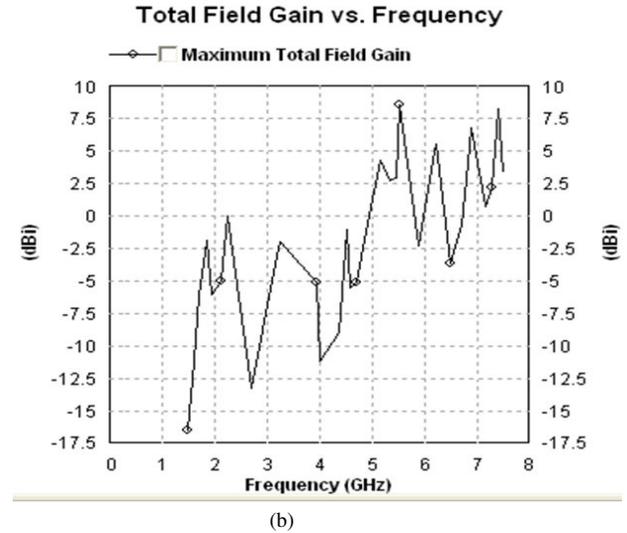
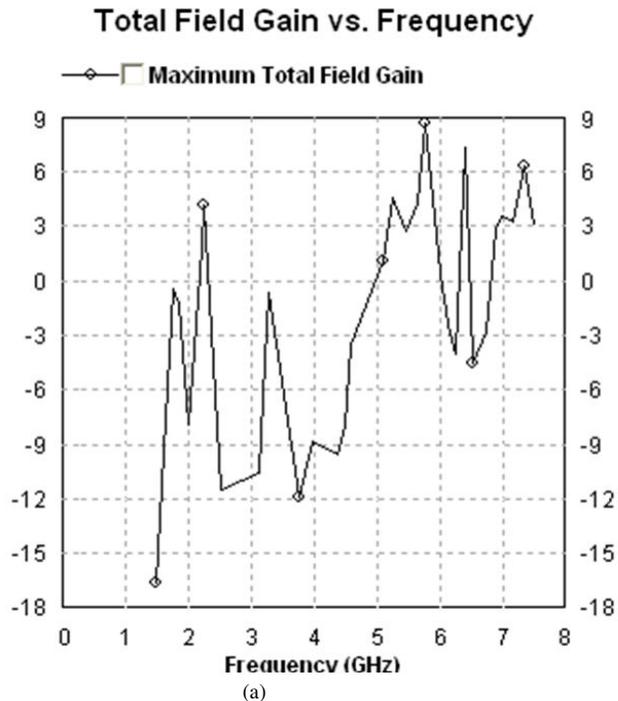


Fig 3 gain vs. frequency
 (a) 1st iteration fractal (b) 2nd iteration fractal

In the below table we tabulate the result from the graphs of fractal antenna with 0's, 1's, 2's iteration to make comparison between them.

Table 1. Parametric Comparison of 0th, 1st, 2nd iteration

Iteration	Centre Frequency (GHz)	Return Loss (dB)	Gain(dB)	Bandwidth (MHz)
Zeroth	2.56	-21.1	5.6	52
First	5.8	-15.4	8.9	72
	6.56	-7.3	7.1	31
	7.01	-12.5	3.8	41
Second	2.26	-22	0.76	42
	3.2	-14.5	-0.4	42
	5.5	-12.8	9.2	56
	6.96	-14.2	7.1	75

Above table shows a parametric comparison of the results obtained after the three iterations. Multiband performance was found to be most suitable in the case of the second iteration.

4. Stacking The Fractal Antenna

The purpose of stacking the fractal antenna is to increase the bandwidth of each band. The stacking of

our fractal has been done till three layers and the resulting bandwidth of each band of the different stacked fractal antennas were compared.

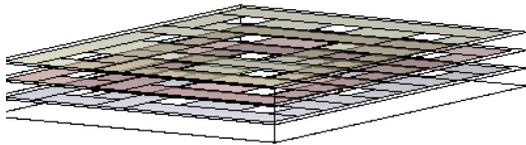
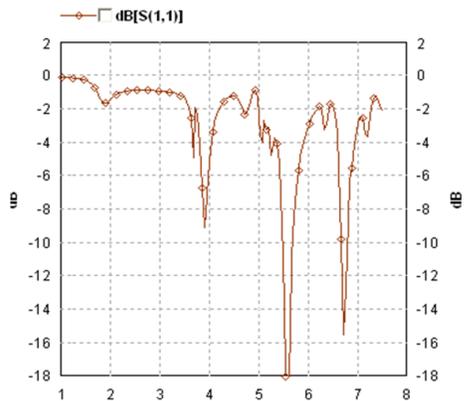


Fig.4 Proposed Geometry of stacked fractal antenna

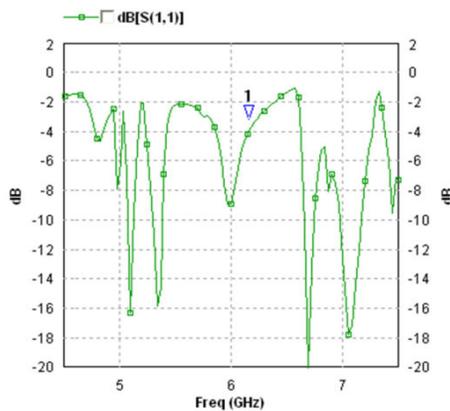
5. Simulation Results Of Stacked Fractal Antenna

5.1. S-Parameter

The following are the s-parameter graphs for a second iteration fractal antenna stacked to two layers and three layers.



(a)

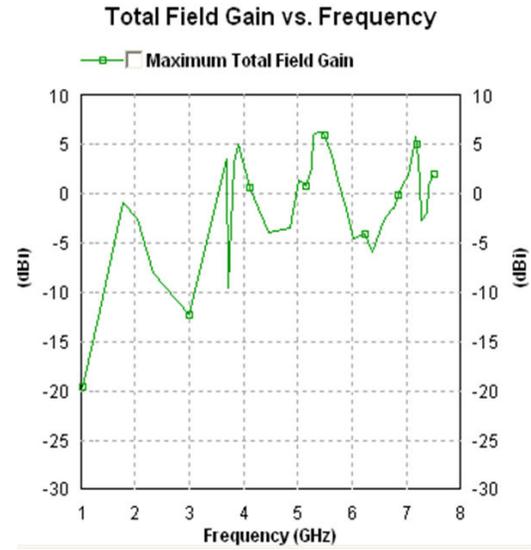


(b)

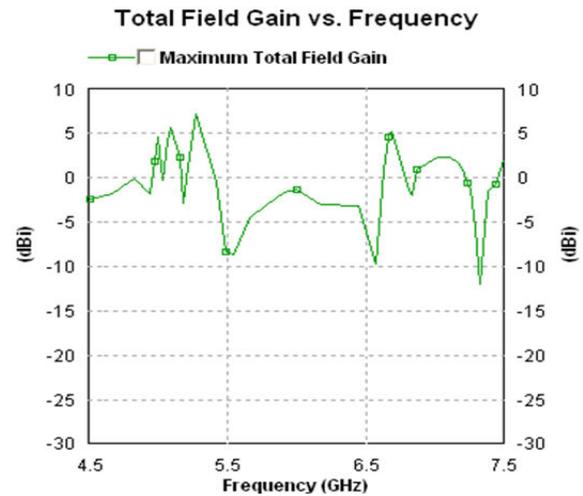
Fig. 5 Return Loss Vs frequency
(a) Two layer stacked fractal antenna

(b) Three layer stacked fractal antenna

5.2. Total Field Gain



(a)



(b)

Fig. 6 Gain vs. Frequency
(a) two layer stacked fractal antenna
(b) three layer stacked fractal antenna

In the below table we tabulate the result from the graphs of stacked fractal antenna to make comparison between them.

Table 2 Parametric study of stack with different layer configuration

No. of layers	Centre Frequency (GHz)	Return Loss (dB)	Gain (dB)	Bandwidth (MHz)
1	5.5	-12.8	9.2	56
	6.96	-14.2	7.1	75
2	5.46	-18	6	205
	6.86	-15.5	3.3	156
3	5.2	-17	5.5	120
	5.5	-16	6	170
	6.8			

From above table we find as number of layer increases bandwidth of antenna increases.

6. Conclusion

The various parameters of different iterative levels have been studied using IE3D simulation tool. Parameters include bandwidth, gain, return loss and centre frequencies. We find that as iteration increases, there is increase in number of bands. Hence fractal geometry is a used to obtain multiband application antennas.

Stacking of 2's iterative fractals has also been performed using IE3D package. We find that with increase in the number of layers of stack, there is improvement in bandwidth.

Finally we get antenna with four operating frequency in C band region with high bandwidth which can be use in high data rate multiband applications.

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