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Optimized SIERPEINSIKI Fractal Antenna with Enhanced Performance Parameters

Roopa.R [1], Dr.Y.S.Kumarswamy [2]
Department of computer Science [1], Rayalaseema University, Kurnool, A.P
Department of Computer Science [2], NJCE, Bangalore
India

ABSTRACT

Today's Wireless communication technology is emerging with the challenge for miniature device with an enhanced performance parameters .Antenna's play an important role in an wireless communication system which converts the electronic signals into Electromagnetic Waves efficiently with minimum loss The conventional antennas designed work well at a particular frequency and perform excellently only at single band /dual band frequencies. In addition, due to the variations that occurs in the frequency, leads to the reduced performances in terms of various parameters. To overcome the disadvantage in the conventional antenna and its different types, new types of antenna called as fractal antenna are designed. Fractal antenna exhibits multiband behavior and has the property of having same shapes of different scales in the antenna geometry it self .In this paper we propose an antenna in the form of sierpinski Square fractal antenna ,which can operate in multiband frequency in the range of 2GHz to 8.2 GHz using computational technique FEM-HFSSV13 Simulator is iterated upto three iterations to achieve enhanced performance parameters such as minimum return loss and enhanced bandwidth and gain . The simulated results are compared with the fabricated results.

***Keywords*:-** Multiband, Fractal antenna, Return Loss, Band width, gain

I. INTRODUCTION

Fractal antenna is an emerging technique which produces an fractal version of all existing antenna types. Benoit.B.MANDELBORT[1] who is the pioneer of fractals defined a fractal as a rough or fragmented geometric shape that can be subdivided in parts, each of which is a reduced size copy of the whole.

The concept of fractals when applied to antenna elements has tremendous advantages in terms of smaller, resonant antennas that are broadband/multiband and may be optimized for gain and this lead to an new type of antenna called fractal antennas.
Fractal antennas are defined as the antennas which are capable of retaining the same shape under recursive transformations, which is an inherent self similarity property shared by many fractals.
Even though fractal antenna is a single antenna, it affords multiband capabilities, with multiple frequencies, increases bandwidth, decreases size load. The main feature is achieving the good and efficient performance parameters even after miniaturization of antenna. In other words we can say that fractal antenna satisfies the requirements of wireless communication systems such as wideband, multiband, low profile and small antenna.
The fractals are distinguishable from classical geometric figures in terms of dimension. A cube, a sphere, and a cone are all simple 3 Dimensional objects. Circles, squares, triangles and other polygons are 2-Dimensional objects. even simpler line is, which is 1-Dimensional.The simplest of all is an infinitely small point, which is Zero-Dimensional .There is another way we can look at simple dimensions, which brings a mathematical significance to the value of the dimension known as Hausfrod dimension:

$$N = r^D$$

N =Total number of objects r=magnification factor.
D= Dimensions of shape, like square,…
taking logarithms,

$$\log(N)=\log(r^D)$$
$$\log(r^D)=D*\log(r)$$
$$D = \log(N) / \log(r)$$

By practical observation, the fractals antenna can have shapes in which can have non –integer values like 1.5, 2,5….,.Therefore each shape in the antenna acquire noninteger values,which is non contradicts to the above dimensional. The shape in the antenna that can have non-integer values, called a *fractal dimension*. Which means that , shapes in the antenna

Types of Fractal antennas

--Deterministic fractal antennas: Always produces the same original object after repetitive recursion at different scaling

Ex:kochsnowflakes,sierpinskigasket,sierpinski carpet

--Random Fractal antennas are quite familiar and many look like random walks. i.e random. Ex: Fractal arrays

The type of fractal antenna choosen in our work is sierpinski carpet which is an square patch antenna consisting of radiating patch on one side of a dielectric substrate and a ground plane on the other side.

Using fractal antennas it is possible to design an compact and multiband antenna for wireless applications. The proposed sierppinski carpet fractal antenna is designed at this work operated at multiband frequencies 2GHz to 8.2 GHz

II. DESIGN

In this work, the antenna is designed to operate in around 2.0 GHz to 8.2 GHz .The design is initiated by choosing the appropriate materials such as FR4 eproxy with ε_r=4.4and dielectric loss tangent of 0.02 and height of substrate 1.58mm.The antenna is excited using 50Ω microstripline.The design steps are as follows:

- Initially ,the construction of sierpinski carpet is obtained by starting with a solid square known as inr base and height of the initiator known as generator(or motif)
- . The dimension is calculated using

D=log N/log(1/a)

- The number of iterations are 3 with the scale factor as 1/3
- In the First iteration the basic patch is divided by 9 small squares and removed the middle square from it,so the remaining squares are 8,by taking scale factor=1/3 and the same process is repeated for next iterations

The microstrip patch antenna with fractal concept and transmission line feed is considered with the initial substrate of 70mmx70mm with transmission line analysis dimensions In the next step design begins with base size of 35.4mm x 35.4 mm and removed the square of size 11.68mm x 11.68mm from the centre of base shape to get the first iteration. This divides the base fractal antenna in a 3-by-3 grid. 1/3 of base square is the size of the removed square , now again subdivide the remaining eight solid squares into 9 equal squares and remove the middle square of size 3.85mm x 3.85mm from each to obtain the second iteration. By using the above procedure sierpinski fractal antenna is designed for three iterations which are shown in the figures below:

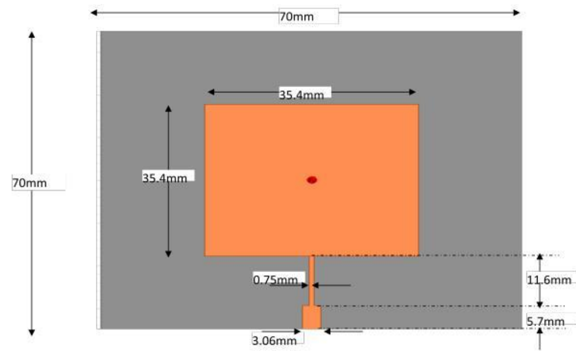
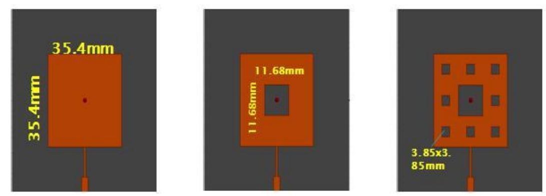


FIG:1



Zero Iteration **FirstIteration** **SecondIteration**

FIG: 2

III. SIMULATION RESULTS

Based on the three iterations of antenna designed the simulated results for various performance parameters are as shown:

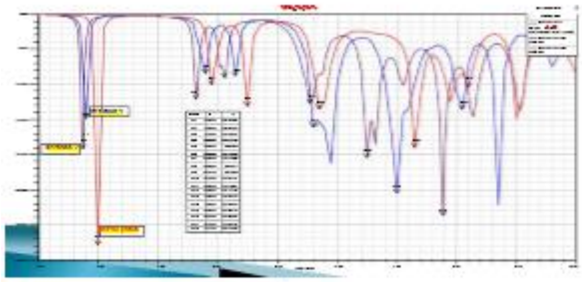


FIG 3

Sl. No.	Iteration-0			Iteration-1			Iteration-2		
	Freq(GHz)	RL (dB)	VSWR	Freq(GHz)	RL (dB)	VSWR	Freq(GHz)	RL (dB)	VSWR
1.	2.0	-32.9	1.06	1.8	-14.9	1.14	1.75	-19.26	1.07
2.	3.9	-10.12	1.21	3.8	-8.49	1.26	3.65	-12.16	1.17
3.	4.5	-13.19	1.18	4.3	-8.80	1.25	4.12	-9.14	1.25
4.	5.7	-13.58	1.15	5.6	-16.14	1.13	5.55	-12.78	1.17
5.	7.3	-19.07	1.11	7.0	-25.59	1.08	6.50	-20.50	1.10
6.	8.2	-10.42	1.21	8.1	-11.63	1.07	7.77	-28.76	1.07

Fig 4

Fabricated antenna are measured for retrun loss by using VNA and Radiation pattern by using Anoeic chamber

Fig5

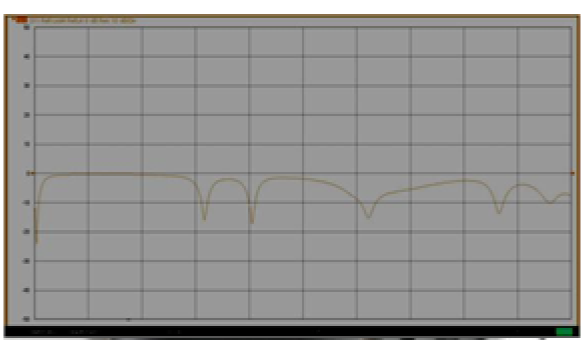


FIG 6

Zero Iteration						
Frequency(simulated)	2.0GHz	3.9	4.5	5.7	7.3	8.2
ReturnLoss(simulated)	-32.9	-10.92	-13.19	-13.58	-19.07	-10.42
Frequency(measured)	2.0GHz	3.8GHz	4.8GHz	5.5GHz	7.4GHz	8.0GHz
ReturnLoss(Measured)	-30.1	-10.7	-15.4	-12.2	-13.6	-7.5
BW(%)	1.8	0.4	1.21	1.3	0.6	0.4

FIG 7

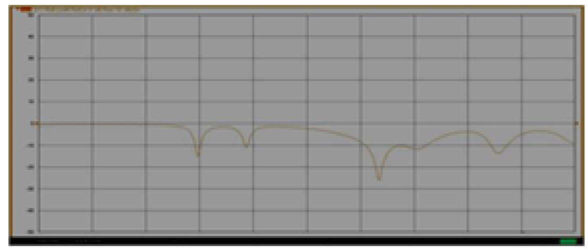


FIG 8

First Iteration						
Frequency(simulated)	1.8GHz	3.8GHz	4.3GHz	5.6GHz	7.0GHz	8.1GHz
ReturnLoss(simulated in dB)	-14.9	-8.49	-8.80	-16.14	-25.59	-11.63
Frequency(measured)	2.0GHz	3.8GHz	4.3GHz	5.6GHz	7.0GHz	8.0GHz
ReturnLoss(Measured)	-10.2	-8.72	-8.80	-20.9	-37..3	-8.5
BW(%)	1.8	1.6	1.4	1.2	0.9	1.3

FIG 9

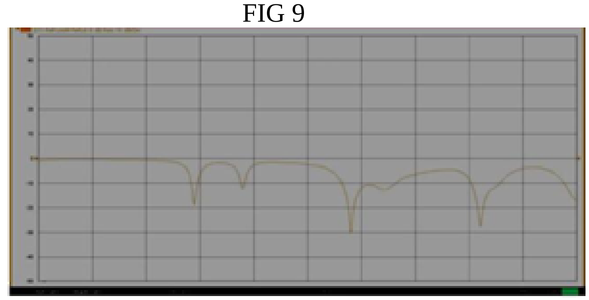


FIG 10

Second Iteration						
Frequency(simulated)	1.75GHz	3.65	4.12	5.55	6.50	7.77
ReturnLoss(simulated)	-19.26	-12.16	-9.14	-12.68	-20.50	-28.76
Frequency(measured)	2.1GHz	3.45	4.3	5.55	6.2	8.0
ReturnLoss(Measured)	-19.6	-10.16	-8.32	-20	-25.3	-37.0
BW(%)	1.7	0.6	1.1	1.4	1.2	1.4

FIG 11

Radiation pattern for fabricated antenna:

Radiation Patterns of iteration2 for various frequencies:

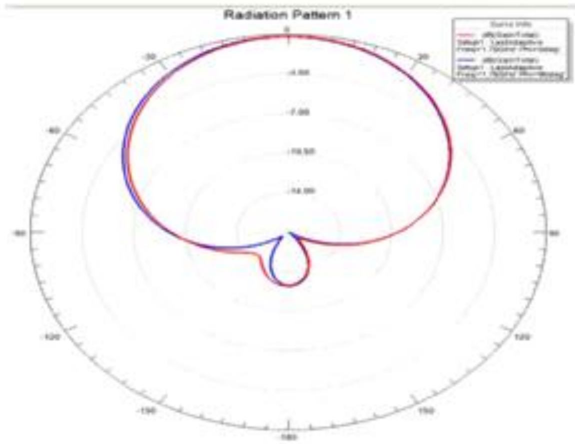


Fig12

F=3.65GHZ Phi='0 deg' gain=11.2dB Phi='90deg' gain=11dB

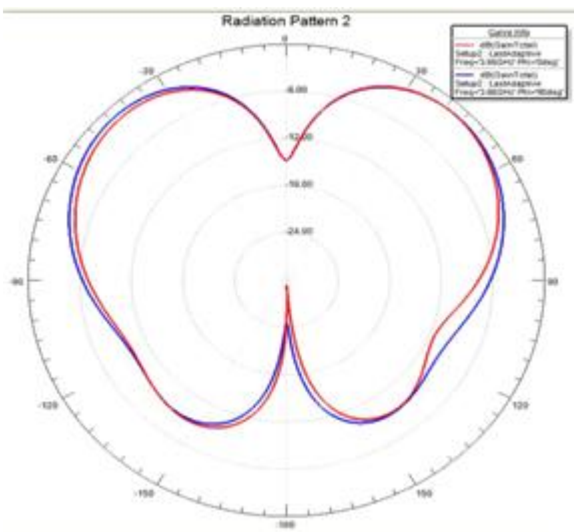


Fig13

F=5.55GHZ Phi='0 deg' gain=11.3dB Phi='90deg' gain=11.3dB

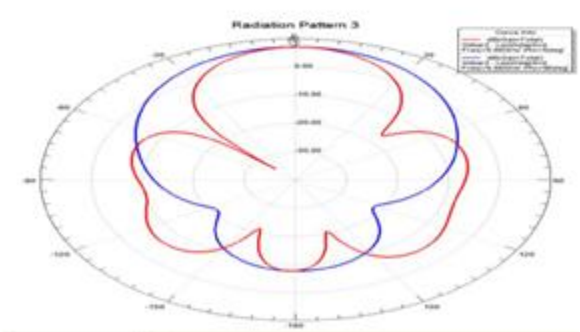


Fig14

F=5.55GHZ Phi='0 deg' gain=11.3dB Phi='90deg' gain=11.3dB

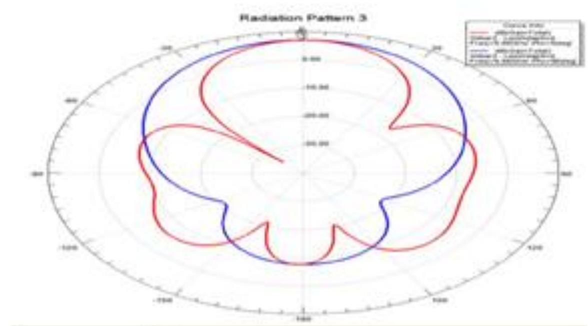


Fig15

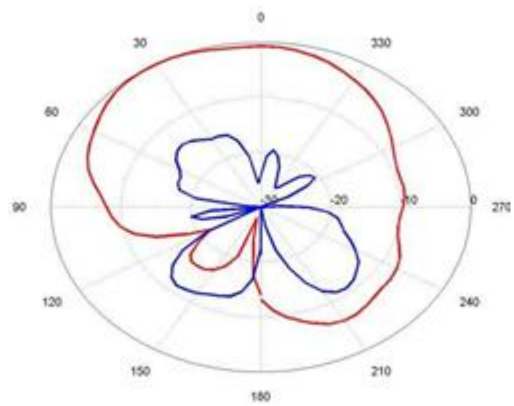


Fig 16
Radiation Pattern for F=1.75 GHZ Phi='0 deg' Phi='90deg'

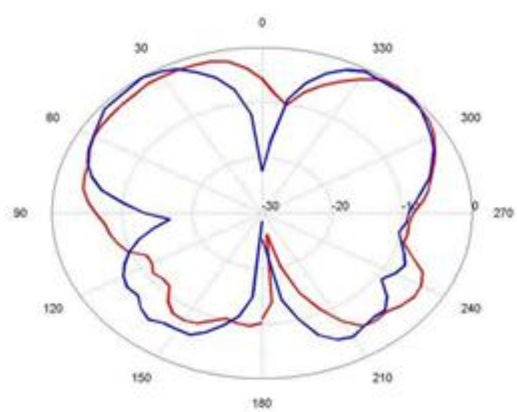


Fig 17: Radiation Pattern for F=3.65 GHZ Phi='0 deg' Phi='90deg'

Zero Iteration						
Frequency(simulated)	**2.0GHz**	**3.9**	**4.5**	**5.7**	**7.3**	**8.2**
ReturnLoss(simulated)	**-32.9**	**-10.92**	**-13.19**	**-13.58**	**-19.07**	**-10.42**
Frequency(measured)	**2.0GHz**	**3.8GHz**	**4.8GHz**	**5.5GHz**	**7.4GHz**	**8.0GHz**
ReturnLoss(Measured)	**-30.1**	**-10.7**	**-15.4**	**-12.2**	**-13.6**	**-7.5**
BW(%)	**1.8**	**0.4**	**1.21**	**1.3**	**0.6**	**0.4**

Table 1: Comparison of the simulated results with the measured results of Zero Iteration

First Iteration						
Frequency(simulated)	**1.8GHz**	**3.8GHz**	**4.3GHz**	**5.6GHz**	**7.0GHz**	**8.1GHz**
ReturnLoss(simulated in dB)	**-14.9**	**-8.49**	**-8.80**	**-16.14**	**-25.59**	**-13.63**
Frequency(measured)	**2.0GHz**	**3.8GHz**	**4.3GHz**	**5.6GHz**	**7.0GHz**	**8.0GHz**
ReturnLoss(Measured)	**-10.2**	**-8.72**	**-8.80**	**-20.9**	**-37..3**	**-8.5**
BW(%)	**1.8**	**1.6**	**1.4**	**1.2**	**0.9**	**1.3**

Table 2: Comparison of the simulated results with the measured results of First Iteration

Second Iteration						
Frequency(simulated)	**1.75 GHz**	**3.65**	**4.12**	**5.55**	**6.50**	**7.77**
ReturnLoss(simulated)	**-19.26**	**-12.16**	**-9.14**	**-12.68**	**-20.50**	**-28.76**
Frequency(measured)	**2.1 GHz**	**3.45**	**4.3**	**5.55**	**6.2**	**8.0**
ReturnLoss(Measured)	**-19.6**	**-10.16**	**-8.32**	**-20**	**-25.3**	**-37.0**
BW(%)	**1.7**	**0.6**	**1.1**	**1.4**	**1.2**	**1.4**

Table 3: Comparison of the simulated results with the measured results of Second Iteration

IV.CONCLUSION

In this research, a square microstrip Sierpinski carpet i.e., modified Sierpinski antenna is constructed using fractal geometry. The designed antenna is to operate in around 2.0 GHz to 8.2 GHz with multiple materials. The simulated results and the measured results indicate that the performance parameters of the designed antenna are enhanced compared with the other research works which exhibits a good radiation and input return loss and significant size reduction. And also the measured results are similar to simulated results at 2.0GHz to 8.2 GHz. As the iteration increases the antenna size in first iteration is reduced by 26% and in second iteration, area is reduced by 11%.Hence the designed antenna is compact enough to be placed in a typical wireless device and this can be further improved.

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