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Design of Compact Sierpeinsiki Fractal Antenna Using Computational Technique

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Abstract:- Wireless communications with optimized device and enhanced performance have been a crucial part of technology in the last few decades .Antenna's play an important role in an wireless communication system as it converts the electronic signals into Electromagnetic Waves efficiently with minimum loss and transmit and receive signals from free space. Traditionally different antenna's are required for different applications i.e. they operate at a single or dual frequency bands. In reality , an antenna is needed which is compact and can operate in multiple frequency for different kinds of applications. But in multiband behavior ,antenna requires a large space and hence limited frequency. To overcome problem in multiband antenna, , different method of antenna design has been proposed and designed, in which an antenna consists of same shapes of different scales in the antenna geometry it self which is known as Fractal antenna .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, Sierpinski Fractal antenna, Return Loss, Band width, gain

I. INTRODUCTION

A fractal antenna is designed using fractal geometry. Fractal means broken or irregular fragments. The Important properties of fractals are[1]:

a)"self similar"—a complex pattern built from the repetition of a simple shape – within the fractal lies another copy of the same fractal, smaller but complete.

b)"Space filling" –In this electrically properties of an antenna has been divided into small electrical properties of small shapes in the antenna geometry, large features which can be efficiently packed into small areas.

c)"simplicity and Robustness"-it is simple due to fractal geometry

d)"broadband"-radiates easily with multiple range of frequencies and is more efficient.

The fractals are distinguishable from classical geometrical figures in terms of dimension . A cube ,a sphere and a cone are all simple 3D objects. Circles , Squares , triangles and other polygons are 2D objects ,even simpler line is 1D . 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 and D= Dimensions of shape, like square

Taking logarithms,

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

Example : For the cube with the factor r=3, there were 27 little cubes in the whole cube. So D = log(27)/log(3) should equal 3, because a cube is a 3-diemnsional object.

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*. This means that, shapes in the antenna can have irregular shape than regular shape like square.

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:

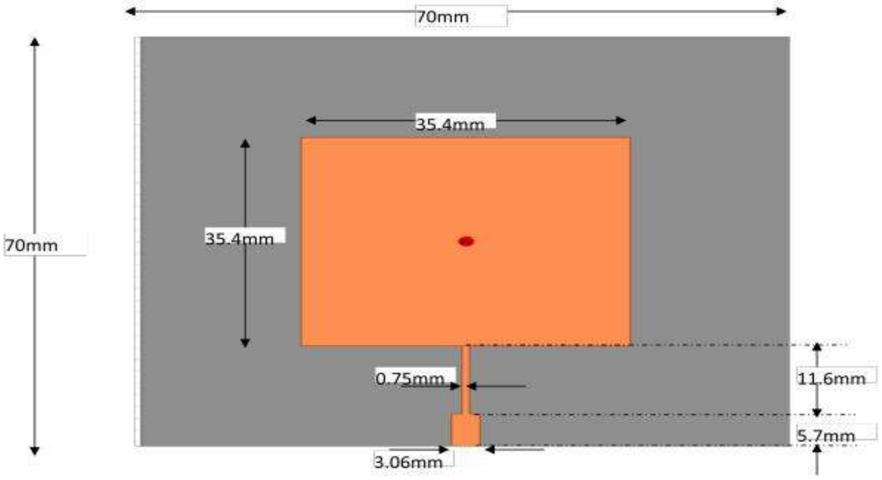
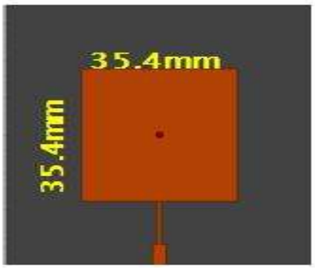
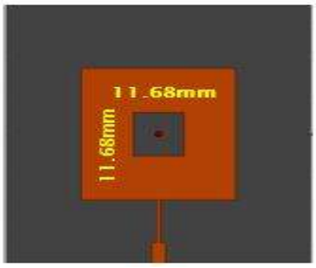


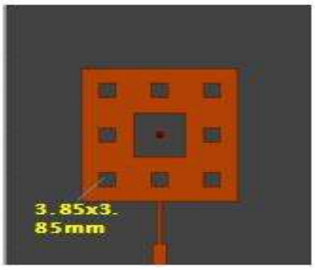
Fig 1



Zero Iteration



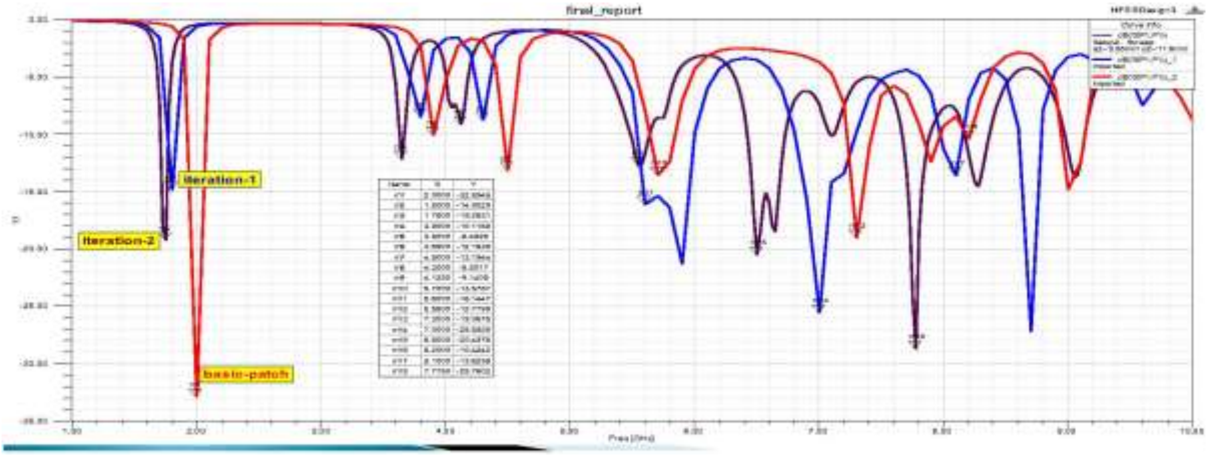
FirstIteration

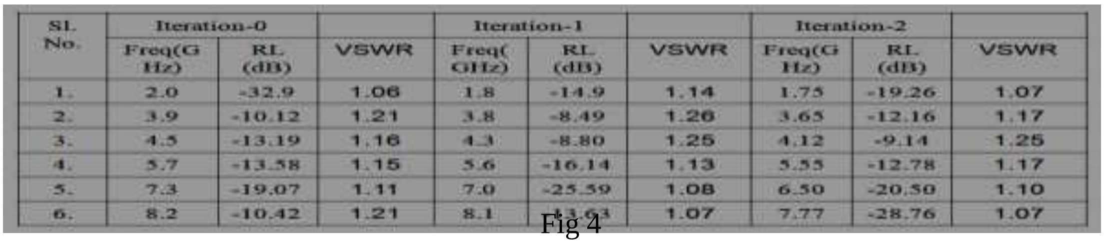


SecondIteration

III. SIMULATION RESULTS

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





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	1.16	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	-13.63	1.07	7.77	-28.76	1.07

Fig 4

Fabricated antenna are measured for return loss by using VNA and Radiation pattern by using Anoehic chamber

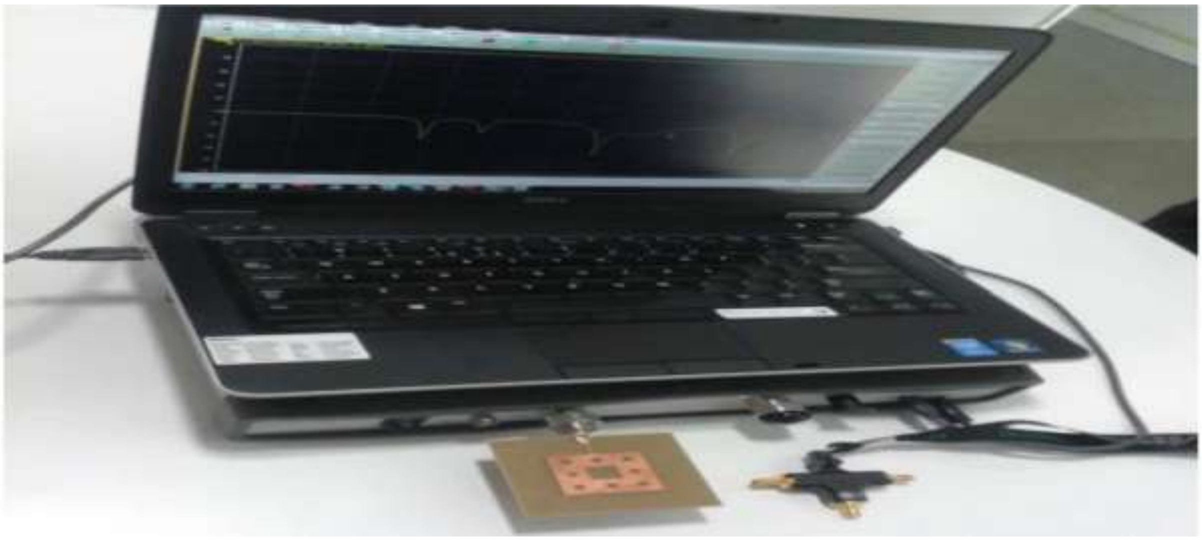


FIG 5

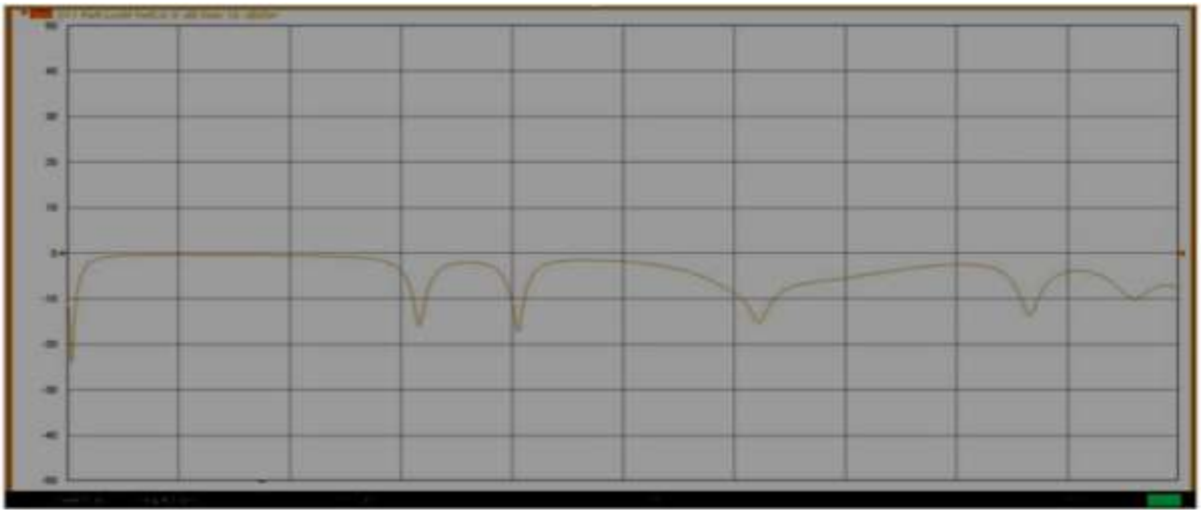
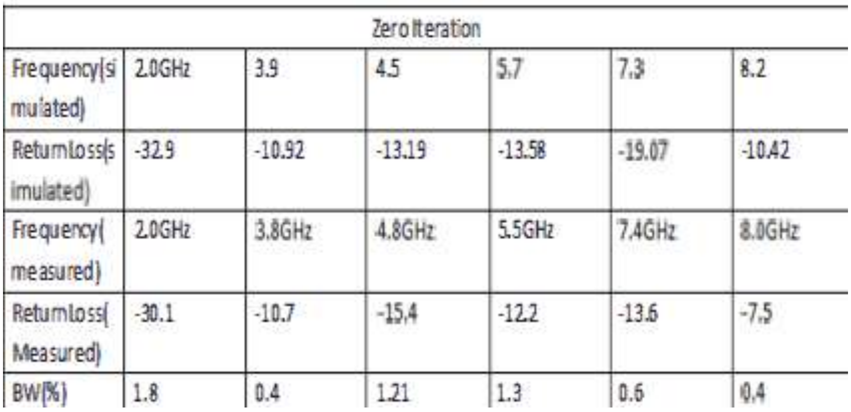


Fig 6



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

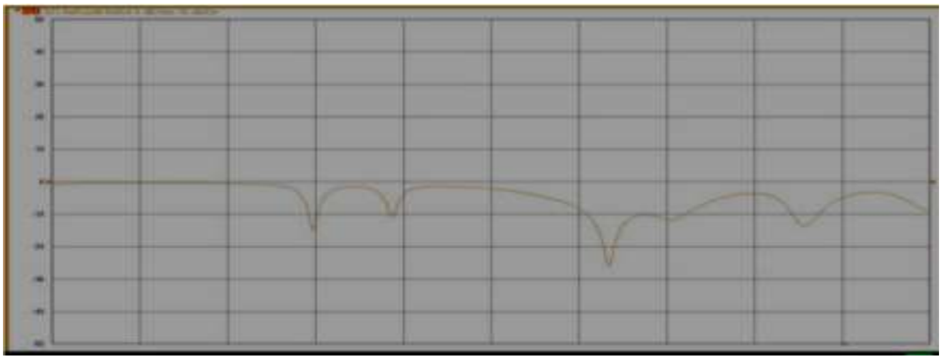
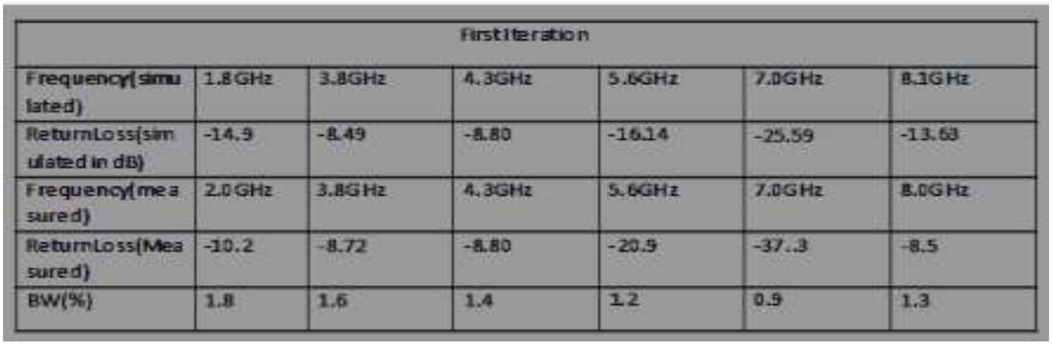


FIG 8



First Iteration						
Frequency(simulated)	1.8GHz	3.8GHz	4.3GHz	5.6GHz	7.0GHz	8.3GHz
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

FIG 9

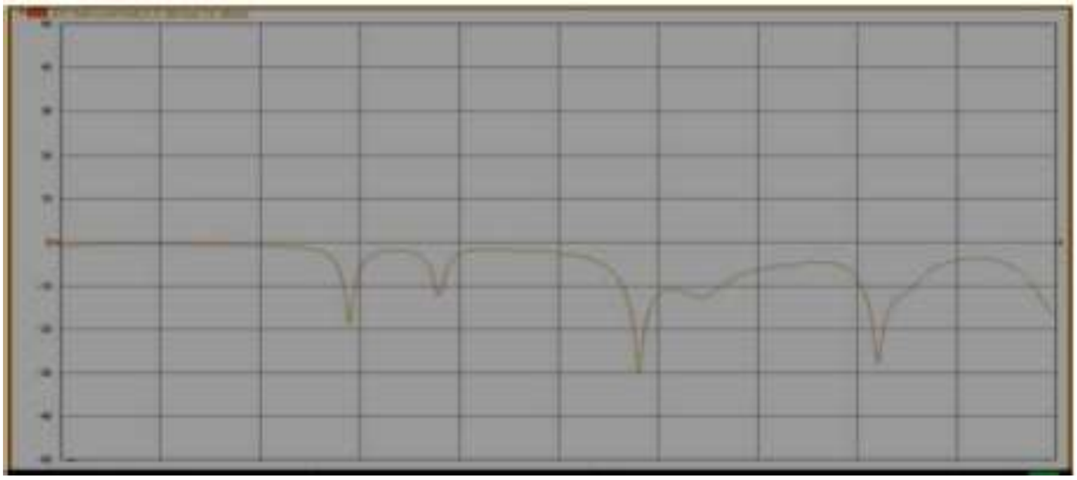
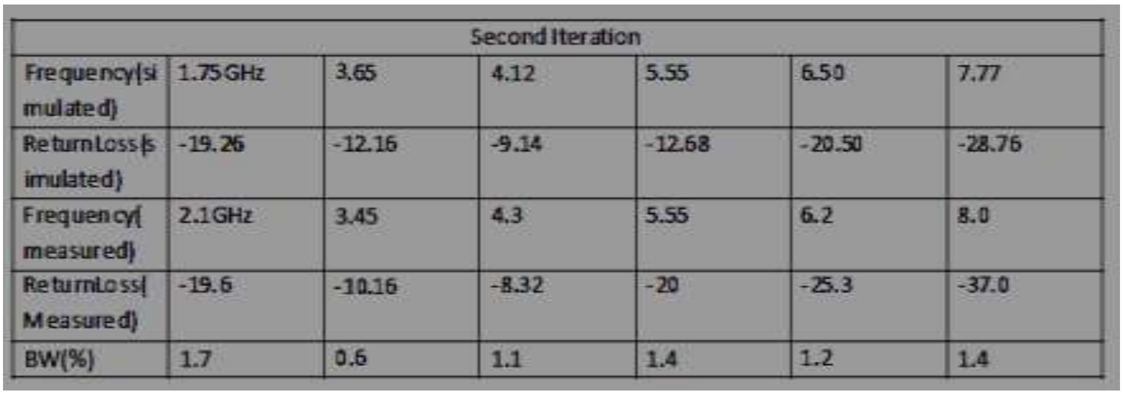
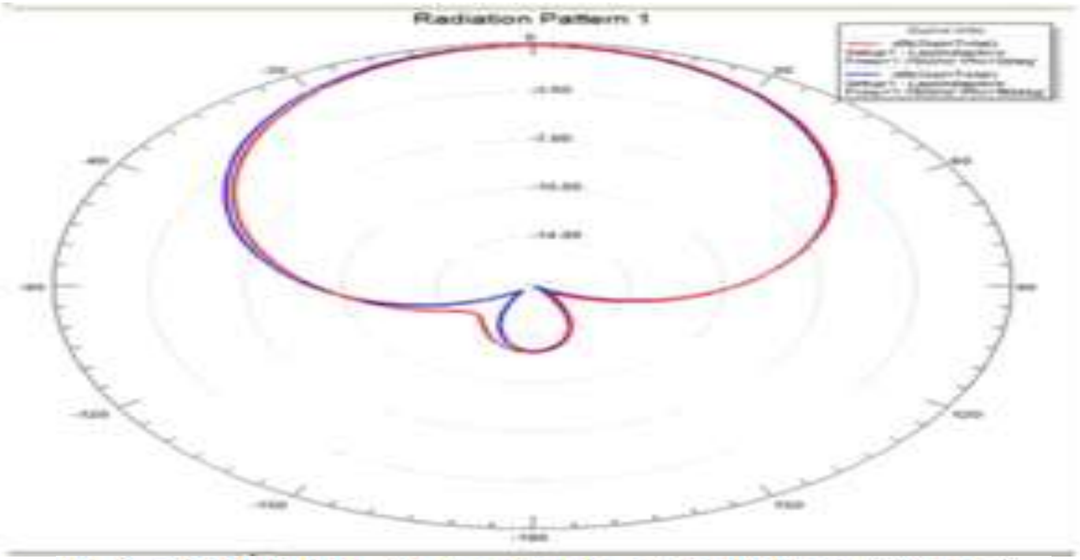


FIG 10



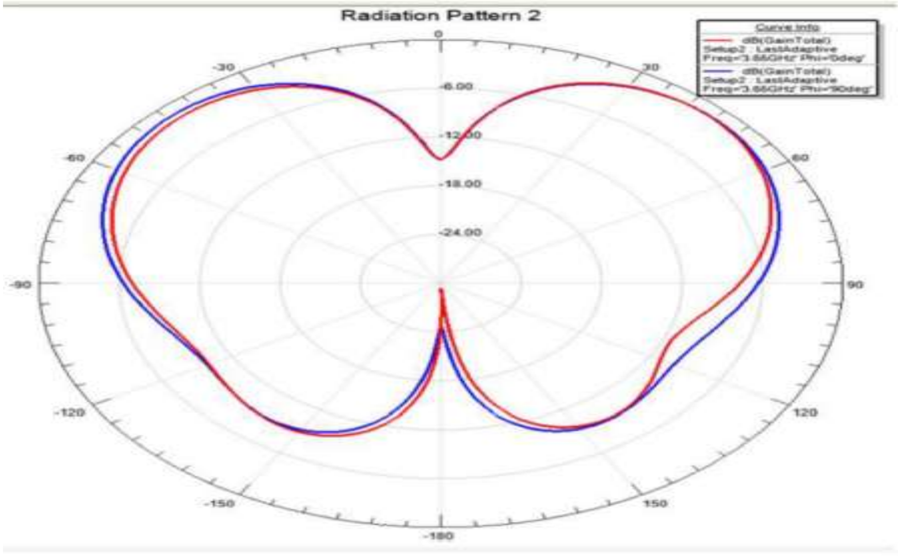
Second Iteration						
Frequency(simulated)	1.75GHz	3.65	4.12	5.55	6.50	7.77
ReturnLoss(simulated)	-19.26	-12.16	-9.14	-12.68	-20.50	-28.76
Frequency(measured)	2.1GHz	3.45	4.3	5.55	6.2	8.0
ReturnLoss(Measured)	-19.6	-10.16	-8.32	-20	-25.3	-37.0
BW(%)	1.7	0.6	1.1	1.4	1.2	1.4

FIG 11



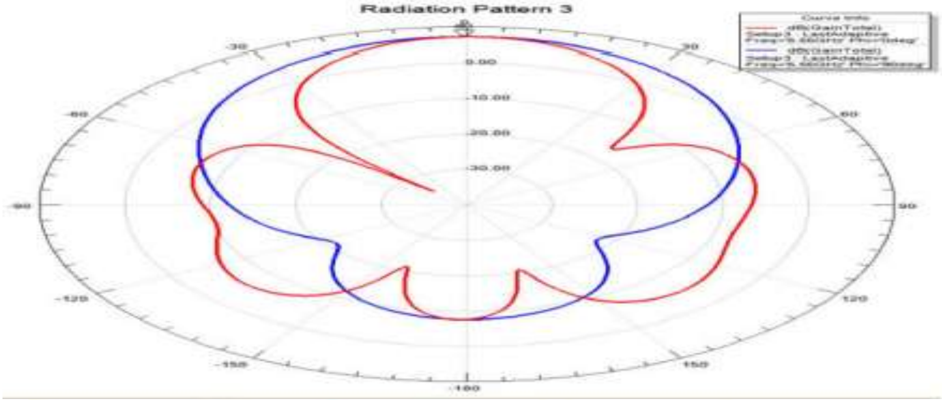
F=1.75GHZ Phi='0 deg' gain=7.2dB Phi='90deg' gain=7.3dB

Fig 12



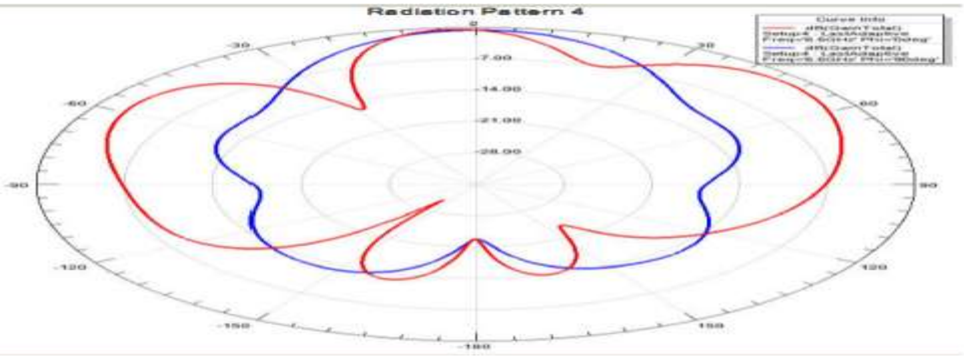
F=3.65GHZ Phi='0 deg' gain=11.2dB Phi='90deg' gain=11dB

Fig 13



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

Fig 14



F=6.6 GHZ Phi='0 deg' gain=7dB Phi='90deg' gain=7dB

Fig 15

IV. CONCLUSION

As the iteration increases the antenna size in first iteration is reduced by 26% and in second iteration , area is reduced by 11%. The return losses are lowest at all iteration and as compared with other works. In each iteration ,the multiband properties has been achieved. where as less bands in other work. Radiation patterns are improved as compared with each iteration and it is better improved pattern. Measured results are similar to simulated results at 2.0GHz to 8.2 GHz. Hence the proposed antenna is multiband and compact enough to be placed in wireless devices

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