DESIGN, SIMULATION AND FABRICATION AND PERFORMANCE EVALUATION OF SIERPINSKI FRACTAL ANTENNA FOR MULTIBAND AND WLAN APPLICATION

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Abstract— **The Sierpinski fractal antenna has been analyzed parametrically, and observed how its characteristics changing with the variation of its different parameters. The input return loss and input impedance have log periodic behavior that characterizes the sierpinski monopole antenna as fractal geometry. The band spacing and impedance matching have been improved by using different scale factor and feeding methods. Sierpinski monopole antenna for WLAN bands (2.4GHz and 5GHz) has been designed and simulated using Ansoft Hfss.The operating frequencies of the proposed designs match with IEEE802.11b (2.45GHz) and IEEE802.11a (5.20 GHz and 5.775GHz) standards which would allow WLAN operation.**
Key words— Sierpinski gasket, Fractal, Input impedance, Gain, Multiband, Input Return loss.
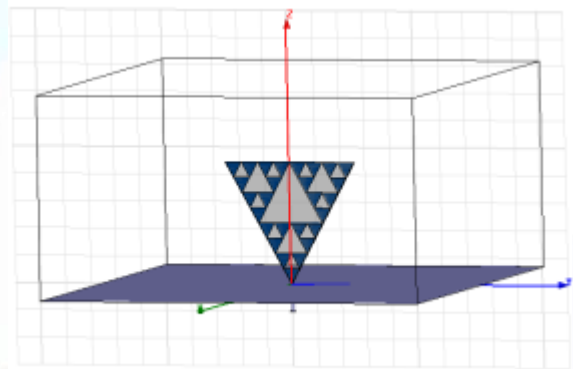
I. INTRODUCTION

Almost all fractals geometry is self-similar characteristics in shapes and structure [1]. Self similarity characteristics of fractal can be seen in its electromagnetic behavior [2]. Sierpinski fractal geometry has been used to design multiband antenna [3].Different fractal shapes have been constructed from Sierpinski fractal to obtain multiband behavior [2]-[7].

The paper involved intense studies about the performance evaluation of Sierpinski monopole antenna and improved radiations and bandwidth to the desired capability of multiband behavior. Modified Sierpinski monopole antenna has been designed and simulated for multiband and WLAN applications.

II. ANTENNA DESIGN

The geometrical construction of sierpinski monopole antenna can be designed by applying decomposition approach or iteration function approach. In fig.1. Sierpinski gasket has been designed based on three iterations, scale factor,

$$\delta = h_n / h_{n+1} = 2. \qquad (1)$$

Where his height and n is natural number and angle of 60o. The sierpinski triangle having 1mm thick FR4 substrate, εr =4.4 and 300 x 300 mm2 with respect to the ground plane. The height, h= 89mm based on fractal analysis in [4].The empirical relation has been taken from [5].

$$f_n = (0.17 + 0.44n)c/h. \qquad (2)$$

The coaxial probe of 50ohms has been used to feed the interior side of the antenna. The air box has been surrounded to create the radiation boundary.

Fig.1. Sierpinski monopole antenna in An soft HFSS.

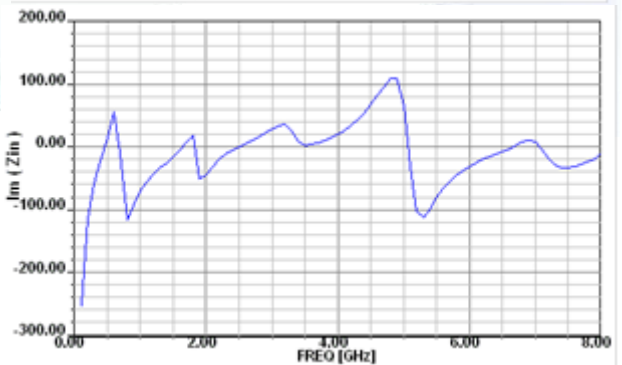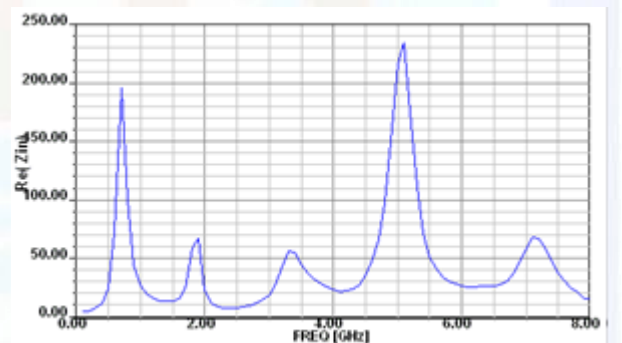### III. SIMULATED AND MEASURED RESULTS

Fig.2. Simulated Input Impedance of Sierpinski Monopole Antenna.

Fig.2. shows the multiband behavior of sierpinski monopole antenna. At the upper three bands the antenna has been perfectly matched and VSWR has less than 2. Also the input

resistance has nearly equal to 50ohms while the input reactance has nearly equal to zero. For multiband behavior, the radiation patterns and input impedance at various resonances should be the same. In the fig. 3, the two dimensional radiation patterns at the three- log period bands, the E-field components at elevation φ =0o and φ =90o and azimuth at θ =90o. The three higher bands have been log periodically spaced in the measured and simulated Return loss.
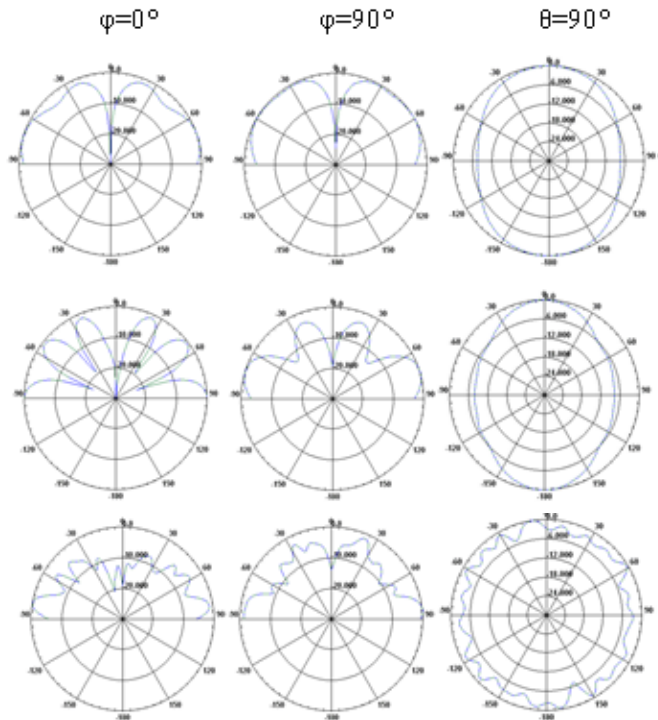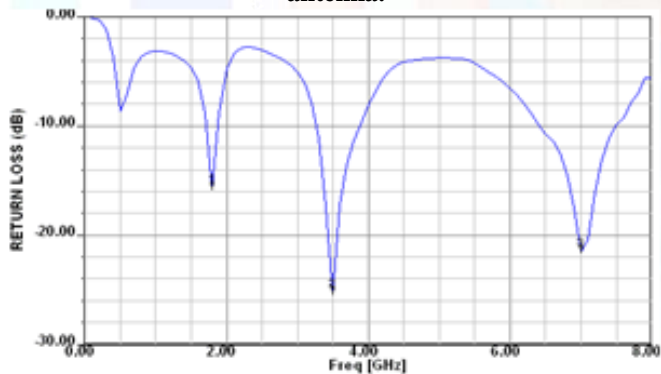

Fig.3. Simulated radiation pattern of sierpinski monopole antenna.

Real: x0= 0.6   x1= 1.9   x2= 3.6   x3= 6.9
Imaginary: y0= -8.70 y1= -15.7 y2= -25.3   y3= -21.5

Fig.4. Simulated Return loss of Sierpinski Monopole Antenna

n bands	f_n (GHz)	BW (%)	L_r (dB)	h_n / λ_n
0	0.5	-	-8.71	3.6
1	1.8	10	-12.45	0.268
2	3.67	23	-35	0.26
3	7.51	17	-14	0.26

Table.2. Measured Return Loss and main parameters of Sierpinski monopole.

Band	I	II	III
Simulated	5	7.1	10.1
Measured	4.8	6.5	7.2

Table.3. Comparison of measured and simulated Gain of sierpinski monopole antenna.

The table.3 shows that with increasing band the simulated gain has been increased, while the measured gain has been decreased due the fact that, FR4 substrate has high dielectric loss tangent. The central triangle play important role in translation of geometrical characteristic into electromagnetic behavior. If the quality factor become low then the bandwidth is large that is why the bandwidth of sierpinski monopole has large at high band.

In order to improve the performance, the geometry of perturbed sierpinski has also been designed by removing the scaled triangle from its parent triangle iteratively, with the scale factor of 1.5 in three iterations. For brevity, only relevant results have been presented. The upper two triangles in each iteration has not exactly replica of parent triangle, that's why the affine transformation of iterative function system has been adopted. Coaxial probe feeding technique has not so profitable. Therefore micro stripe feeding technique has been used. The antenna has been printed on FR4 substrate, εr = 4.4, thickness 0.5mm and micro stripe feeding line of 50ohms. The low resistance of monopole has been increased and matching has improved.
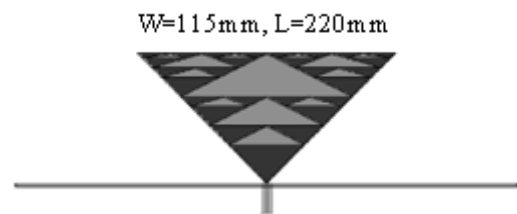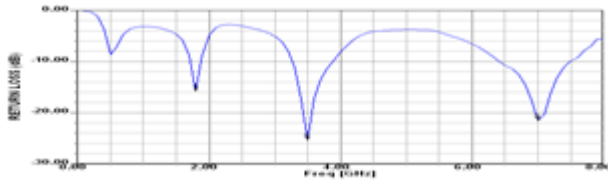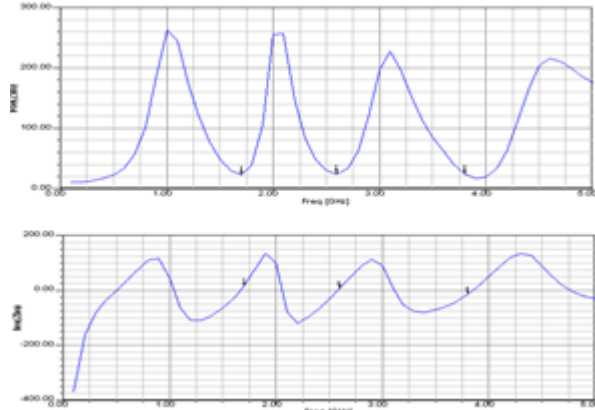

Fig.8. Perturbed sierpinski Antenna of scale factor 1.5.

Bands (n)	f (GHz)	L_r (db) simulated	L_r (db) measured	$f_n + 1/f_n$
0	0.5	-8.68	-30.8	3.4
1	1.7	-8.28	-36.5	1.53
2	2.6	-9.59	-21.8	1.46
3	3.8	-9.04	-18.6	1.26

Table.10 Main parameter of simulated and measured input returns loss of perturbed sierpinski monopole.
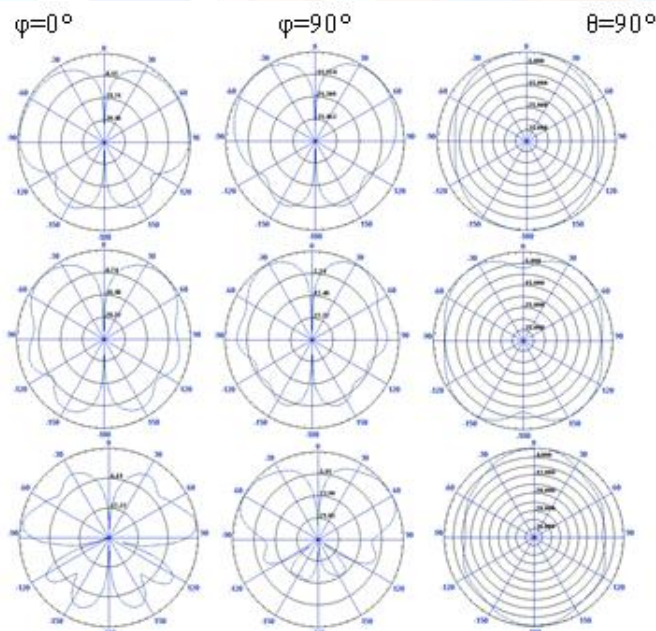
Fig.9. Simulated Return loss perturbed Sierpinski Monopole with microstrip feed.

Real: x1= 1.7   x2=2.6   x3=3.8
Real   x1= 1.7   x2=2.6   x3=3.8
Imaginary: y1=23.7 y2=24   y3=24.7
Real: x1=1.7   x2=2.6   x3=3.8
Imaginary: y1=16.2 y2=7.7   y3=13

Fig.10. Simulated Input impedance of Perturbed Sierpinski Monopole (Real and Imaginary).

The bands have been well matched and antenna has the log periodic behavior. Band spacing has been adjusted according to the scale factor at the cost of low input impendence matching. The first band still opposes the log periodicity due to the effect of truncation. This is the fundamental frequency of large gasket triangular monopole antenna.

Fig.11. Simulated Radiation patterns of Perturbed Sierpinski Monopole with microstrip feed.

It has been concluded that the resonant frequencies have same position and input return loss has three log-periodic bands spaced and log period of 1.5. The only deviation has in the third log-periodic band of the measured result have ripples (3.8 GHz). In table 10 gain of antenna at three log periodic bands spaced and scale factor of 1.5 which has less than normal ground plane antenna due to the loss of antenna image in the perpendicular ground plane, also studied in [6].

(n)	Frequency(GHz)	Simulated Gain	Measured Gain
I	1.6	3	6.2
II	2.5	3	1.7
III	3.8	4	2

Table.10. Measured and Simulated Gain of perturbed monopole antenna.

As compared with classical Sierpinski monopole antenna the perturbed monopole have low overall gain because the radiation has towards the ground plane in classical sierpinski monopole antenna which has been reflected from upper half space and has been improved in upper space.
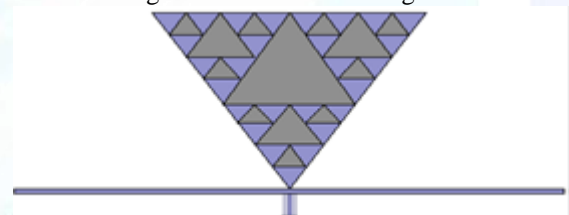
IV. SIERPINSKI MONOPOLE FOR WLAN BAND

The sierpinski monopole antenna has also been designed for WLAN band 2.4GHz and 5GHz.The physical parameters have been taken from the relation;

$$f_n = 0.26c\delta_n/h \qquad (3)$$

Where fn = 2.5GHz, and fn+1 = 5GHz.So fn/fn+1 =2.08 approximately equal to 2. Considered the iteration three, having resonate frequencies of fo and f3.

Physical Parameter	Value
Scale factor, δ	2
Flare angle	60degree
Height of largest gasket, h	65mm

On the biases of these physical parameters sierpinski monopole antenna in fig. 5, for WLAN bands 2.4GHz and 5GHz has been designed and simulated using An soft HFSS.
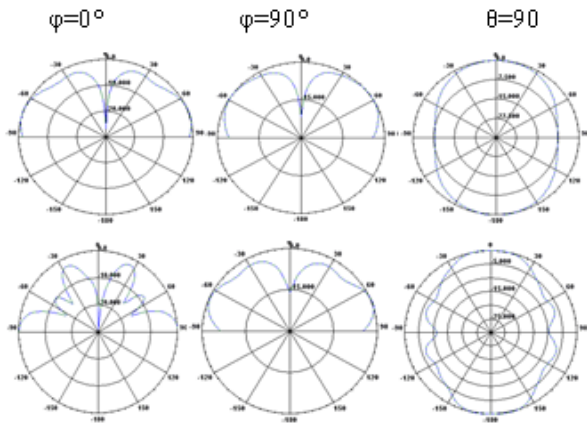

Fig. 5. Sierpinski monopole antenna for WLAN band.
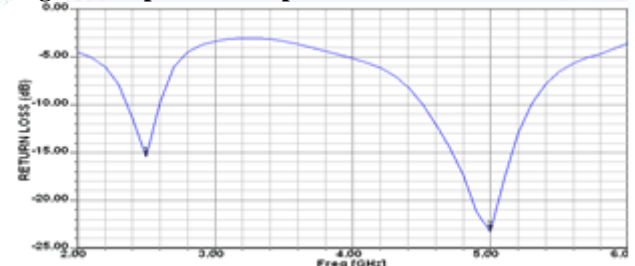
Fig.11. Simulated Return loss of Sierpinski Monopole for WLAN bands.

φ=0°   φ=90°   θ=90

Fig.12. Simulated Radiation Patterns of Sierpinski Monopole for WLAN bands.

V. CONCLUDING REMARKS

The sierpinski fractal antenna has been designed, simulated and fibricated.The measured and simulated results of different parameters have been compared and bring improvement in impedance matching, bands spacing, radiations and bandwidth of the proposed antenna to some extent. The sierpinski monopole antenna for the practical application WLAN bands has been designed and analyzed.For practical uses consider the curved ground plane and multiple scale factors. In cellular communication the sierpinski dipoles can be used at the place of triangular array of dipole.

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