DESIGN AND ANALYSIS OF SIX SHAPED LOADED MICROSTRIP ANTENNA FOR MULTI-FREQUENCY APPLICATION IN L-BAND

Manoj Kumar[1], Mohit Gaharwar[2]
[1,2]Electronics & Communication Engineering Department
[1,2]Sachdeva Institute of Technology
Mathura, India

Abstract— In this design study, the main purpose was to design a six shape micro strip antenna. Previous works are also dealing with the bandwidth increasing techniques by changes on the geometry. Some articles and applications are examined about micro strip antennas. There is a six shape antenna which operates in L band, but they do have a wider bandwidth. The development of antenna for wireless communication also requires an antenna with more than one operating frequencies. This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies. However, the general micro strip patch antennas have some disadvantages such as narrow bandwidth etc. Enhancement of the performance to cover the demanding bandwidth is necessary. Among these standards, the following frequency bands can be mentioned:1) PCS-1900 requires a band of 1.85 - 1.99 GHz; 2) IEEE 802.11b/g requires a band of 2.4 - 2.484 GHz; 3) IEEE 802.11a requires a band of 5.15 - 5.35 GHz and an additional band of 5.725 - 5.825 GHz; 4) HiperLAN2 requires a band of 5.47 - 5.725 GHz besides the band of 5.15 - 5.35 GHz. Microstrip antennas are very attractive because of their low profile, conformal to the surface of objects and easy production.

Keywords: - Microstrip antenna, VSWR, Gain, Return Loss, HFSS Software etc.

1. INTRODUCTION

Modern telecommunication systems require antennas with wider bandwidths and smaller dimensions than conventionally possible. This has initiated antenna research in various directions, one of which is by using fractal shaped antenna elements. In recent years several fractal geometries have been introduced for antenna applications with varying degrees of success in improving antenna characteristics. Some of these geometries have been particularly useful in reducing the size of the antenna, while other designs aim at incorporating multi-band characteristics. Yet no significant progress has been made in corroborating fractal properties of these geometries with characteristics of antennas. The research work presented here is primarily intended to analyze geometrical features of fractals that influence the performance of antennas using them. In this work the multi-band (multifunctional) aspect of antenna designs are explored further with special emphasis on identifying fractal properties that impact antenna multi-band characteristics. Antennas with reduced size have been obtained using Hilbert curve fractal geometry. Furthermore, design equations for these antennas are obtained in terms of its geometrical parameters such as fractal dimension.

2. FEEDING METHODS

There are several techniques available to feed or transmit electromagnetic energy to a microstrip antenna. The four most popular feeding methods are the Microstrip line, coaxial probe, aperture coupling and proximity coupling.

2.1.1 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 2.19, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

2.1.2 Microstrip Feed line

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element.

2.1.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the Microstrip feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centred under the patch, leading to lower cross polarization due to the symmetry of the configuration.

2.1.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth.

3. MATHEMATICAL FORMULAE'S AND DESIGN

i: **Calculation of the Width (*W*):**

The width of the Microstrip patch antenna is given by equation as:

$$w = \frac{c}{2f\sqrt{(\varepsilon_r + 1)/2}}$$

ii: **Calculation of Effective dielectric constant (ε_{reff})** :

The following equation gives the effective dielectric constant as

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_r}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2}$$

iii : Calculation of the Effective length (L_{eff}):

The following equation gives the effective length as:

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}}$$

iv: Calculation of the length extension (Δ*L*):

The following equation gives the length extension us:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff+0.3})}{(\varepsilon_{reff-0.258})}\frac{(\frac{W}{h} + 0.264)}{(\frac{W}{h} + 0.8)}$$

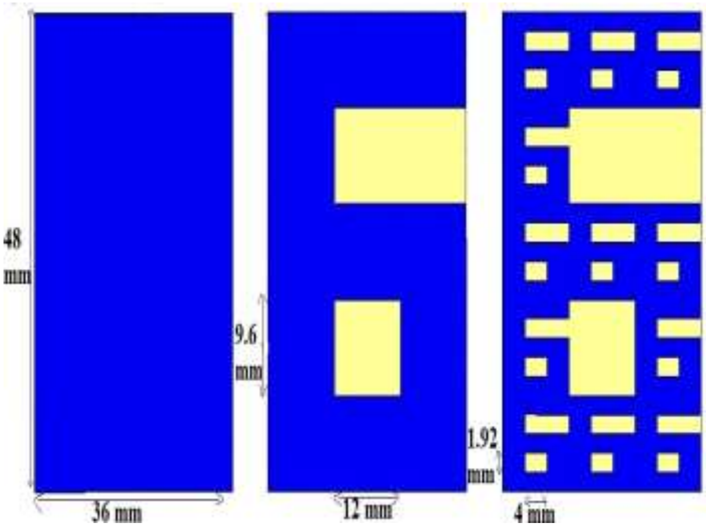

Fig. (a) First two iterations of the fractal geometry

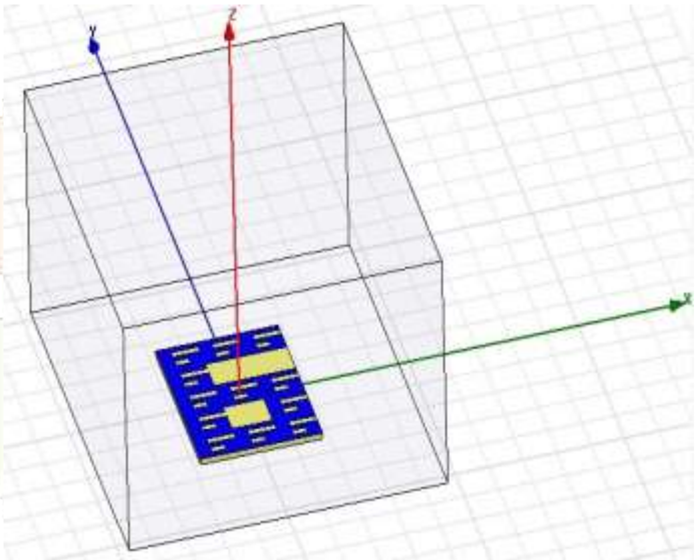

Fig.(b) Coaxial feeded iterated fractal geometry (K2) in radiation Box

4. RESULTS AND DISCUSSION

In this research paper all results are calculated using HFSS software. Return loss, VSWR and radiation pattern is shown in figure c, d, e, f, h respectively. All parameters are calculated for L Band. The best result is coming on 2.423 GHz frequency so on the basis of result 2D, E and H plane are calculated.

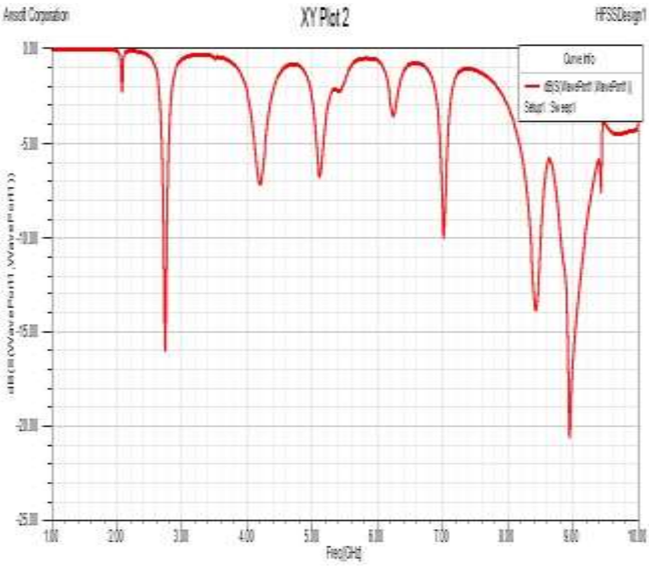

Fig. (c) Return loss of the initiator geometry (K0)

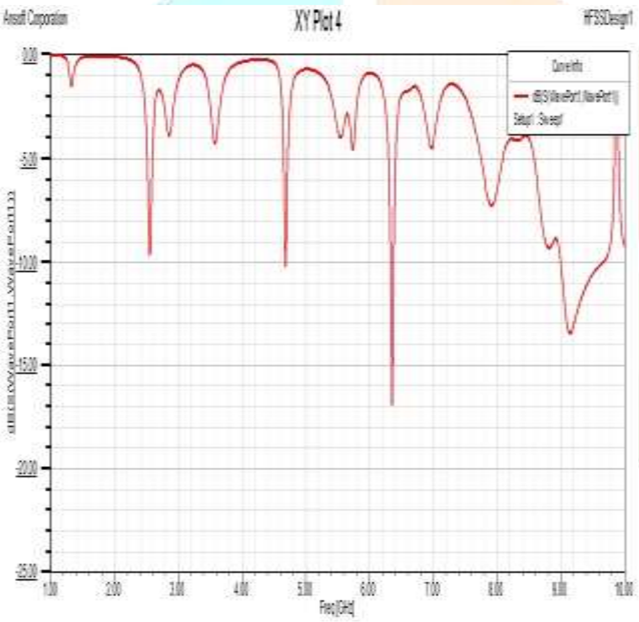

Fig. (d) Return loss of the generator geometry (K1)

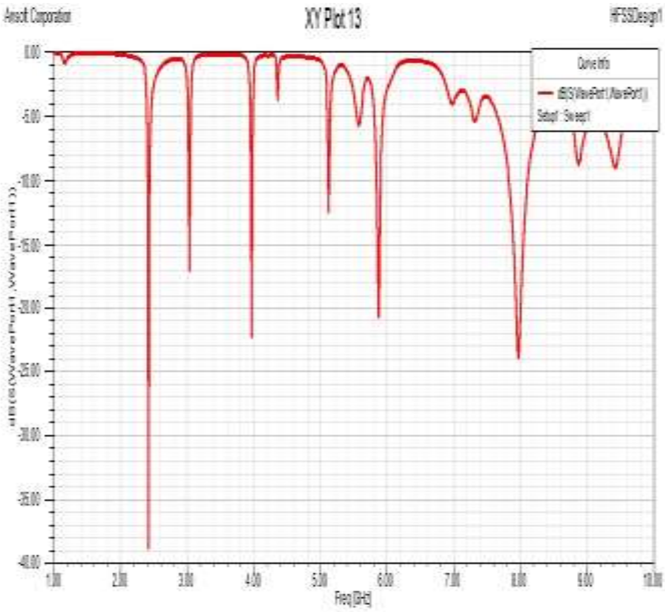

Fig. (e) Return loss of the iterated geometry (K2)

TABLE I. SIMULATED RESULTS OF FRACTAL ANTENNA

Fractal Structures	Resonance Frequency	Return Loss	Bandwidth	VSWR
K0 (INITIATOR)	2.747 GHz (2.720 – 2.765 GHz)	-15.959 dB	45.00 MHz	1.378
	8.432 GHz (8.351 – 8.504 GHz)	-13.886 dB	153.0 MHz	1.506
	8.954 GHz (8.819 – 9.180 GHz)	-20.584 dB	361.0 MHz	1.206
K1 (GENERATOR)	4.684 GHz (4.675 – 4.693 GHz)	-10.188 dB	18.00 MHz	1.896
	6.351 GHz (6.330 – 6.375 GHz)	-16.936 dB	45.00 MHz	1.331
	9.135 GHz (8.995 – 9.648 GHz)	-13.404 dB	653.0 MHz	1.543
K2 (ITERATED STRUCTURE)	2.423 GHz (2.410 – 2.440 GHz)	-38.816 dB	30.00 MHz	1.023
	5.873 GHz (5.840 – 5.905 GHz)	-20.663 dB	65.00 MHz	1.204
	7.972 GHz (7.830 – 8.110 GHz)	-23.910 dB	280.0 MHz	1.136

It is observed from Table-I that self affined 6 shape fractal antenna (K2) having multiband characteristics. Initial basic structure (K0) and generator structure (K1) also having multiband characteristics but less than iterated structure (K2). Show we proved fractal structure having multiband characteristics with good returnloss and VSWR. However we compromised with bandwidth but it usually occurs when we improves reflection coefficient.

Fig.(f) and Fig. (g) shows the 2 Dimensional E (Elevation) and H (Azimuth) radiation patterns respectively on resonant frequencies for iterated fractal structure (K2). Where as Fig.(h) shows the 3 Dimensional radiation patterns for iterated fractal structure (K2).

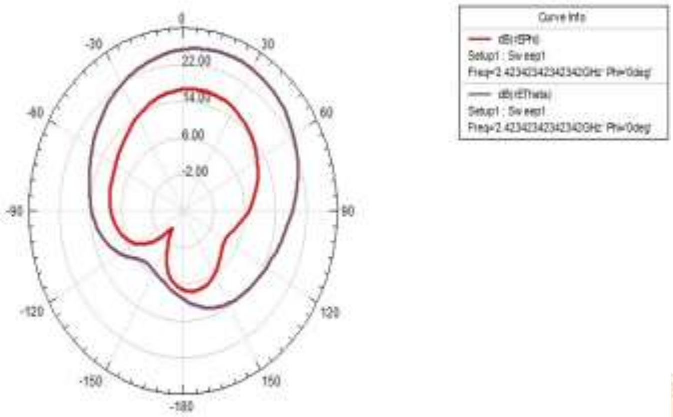

Fig (f): 2D E-plane Radiation pattern of second iterated (K2) fractal antenna at2.423 GHz

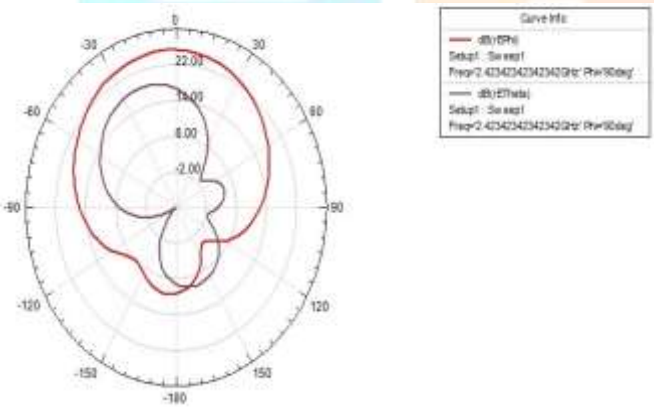

Fig. (g): 2D H-plane Radiation pattern of second iterated (K2) fractal antenna at 2.423 GHz

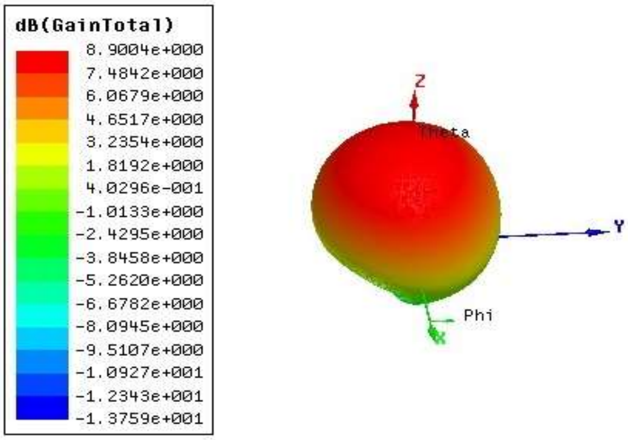

Fig. (h) : ***3D Radiation pattern of second iterated (K2) fractal antenna at 2.423 GHz***

5. DISCUSSED FUTURE WORK

The proposed antenna will be fabricated and measured result will be compared with simulated results. After fabrication it will be operated in the given conditions and the radiation pattern will be analyzed. The errors will be minimized by using given tools. Matching techniques could also be used to try to reduce the return loss in antennas and cover all types of fractal antennas with small size.

For this project the Sierpinski carpet geometry was used, but other structures could be used. Other geometries could be simulated and described and finally compared so the best geometry for a certain application could be found. Usually the size of the antenna is very important, mainly for wireless applications so other fractal geometries need to be tested to achieve a reduced size with the best performance.

REFERENCES

[1] C. Puente, J. Romeu, R. Bartoleme, and R. Pous, "Fractal multiband antenna based on Sierpinski gasket," Electron. Lett., vol. 32, pp. 1-2, 1996.

[2] C. Puente-Baliarda, J. Romeu, R. Pous, and A. Cardama, "On the behavior of the Sierpinski multiband fractal antenna," *IEEE Trans. Ant. Propagat.*, vol. 46, pp. 517-524, 1998.

[3] N. Cohen, "Fractal antenna applications in wireless telecommunications," in Professional Program Proc. of Electronics Industries Forum of New England, 1997,IEEE, pp. 43-49, 1997.

[4] C. Puente-Baliarda, J. Romeu, R. Pous, J. Ramis, and A. Hijazo, "Small but long Koch fractal monopole," Electron. Lett., vol. 34, pp. 9-10, 1998.

[5] D.H. Werner, R.L. Haupt, and P.L. Werner, "Fractal antenna engineering: The theory and design of fractal antenna arrays," IEEE Ant. Propagat. Mag., vol. 41, no. 5, pp. 37-59, 1999.

[6] D.H. Werner, P.L. Werner, D.L. Jaggard, A.D. Jaggard, C.Puente, and R.L. Haupt, "The theory and design of fractal antenna arrays," Frontiers in Electromagnetics, D.H. Werner and R. Mittra (Eds.), pp. 94-203, 1999.

[7] D.H. Werner, P.L. Werner, and A.J. Ferraro, "Frequency independent features of self-similar fractal antennas," IEEE AP-S Inter. Symp. 1996, pp. 2050-2053, 1996.

[8] D.H. Werner and P.L. Werner, "Frequency independent features of self-similar fractal antennas," Radio Science, vol. 31, pp. 1331-1343, 1996.

[9] B.B. Madelbrot, *The Fractal Geometry of Nature*, New York: W.H. Freeman, 1983.

[10] H.O. Peitgen, H. Jurgens, and D. Saupe, Chaos and Fractals: New Frontiers of Science, New York: Springer-Verlag, 1992.

[11] K.J. Falconer, Fractal Geometry: Mathematical Foundations and Applications, New York: Wiley, 1990.

[12] K.J. Vinoy, “Fractal shaped antenna elements for wide and multi band wireless applications,” Ph.D. dissertation, Univ. of Pennsylvania,August 2002.

[13] K. L. Wong, Planar Antennas for Wireless Communications, Wiley-Interscience, John Wiley & Sons, 2003.

[14] Y. Rahmat-Samii, and J.P. Gianvittorio, ―Fractal Antennas: A Novel Antenna Miniaturization Technique and Applications,‖ IEEE Antennas and Propagation, vol.44, no. 1, pp. 20–36, February 2002.

[15] D. Manteuffel, “Design Considerations for Integrated Mobile Phone Antennas”, Proceedings of the 11th International Conference on Antennas and Propagation, vol.1, pp. 252–256, April 2001.

[16] P. Vainikainen, “Performance Analysis of Small Antennas Mounted on Mobile Handsets”, Proceedings of the COST 259 Final Workshop–Mobile and Human Body Interaction, pp. 8, 2000.