**Proceedings of the 2009 IEEE 9th Malaysia International Conference on Communications**
**15 -17 December 2009 Kuala Lumpur Malaysia**

# A New Fractal Monopole Antenna For Super Wideband Applications

Abolfazl Azari (Member, IEEE)
*Member of Young Researchers Club*
*Islamic Azad University, Gonabad Branch*
*IRAN*
azari@ieee.org

*Abstract*— **Modern wireless communication systems need antennas with further bandwidth and smaller size. Fractals have unique properties such as self-similarity and space-filling. The concepts of fractals can be applied to the design of low profile and multi-band antennas.**
**In this paper, a 40GHz super wideband antenna with applying a new fractal geometry to a wire monopole antenna is presented. Modelling and simulation is performed using SuperNEC electromagnetic simulator. Results of simulation show that proposed antenna is applied in 11-52GHz frequency range. Radiation patterns are also studied.**

*Keywords*— **Bandwidth, fractals, fractal antenna, wideband.**

## I. INTRODUCTION

With the advance of wireless communication systems, low profile and wideband antennas are requested for commercial and military applications greatly. Customarily, wideband antenna need different antenna elements for different frequency bands. Also, if antenna size is less than a quarter of wavelength, antenna will not efficient because radiation resistance and bandwidth are reduced. Recent researches in the study of fractal antennas suggest some good solutions for designing multi-band and small size antennas[1-4].

Fractals build by self-similar elements which are iterated in various directions and increasing iterations does not change their total form. Self similarity of fractals is the cause of multi-band behaviour whereas their convoluted and jagged shapes increase bandwidth and effective radiation of antennas. Also, fractals can be placed long electrical lengths into small volume using their ability of space-filling which this property miniaturize antenna elements [5 - 9].

Several wire antenna configurations based on fractal geometries have been investigated including Koch, Minkowski, Hilbert and fractal trees antenna in recent years. These antennas have been simulated using the moment method as well as fabricated and measured.

In this paper another shape of fractal is presented. With applying this fractal generator to a wire monopole antenna, we have achieved to a super wideband antenna.

The method of moment has been used for simulation of the proposed antenna based on SuperNEC electromagnetic simulator.

The simulated results show that proposed antenna has 40GHz bandwidth including 11-52GHz frequency range with VSWR<2.

## II. ANTENNA STRUCTURE

This fractal antenna is an iterative model to a wire monopole antenna with a generator of the shape shown in figure 1. The length of each straight segment at proposed generator is 2mm. W (indentation width scalling) usually changes between 0 to 1, and here W=0.5 that means the length of indentation is equal to half of the straight sections. Therefore the length of indentations is 1mm. Also, the indentation angle $\theta = 45^\circ$.

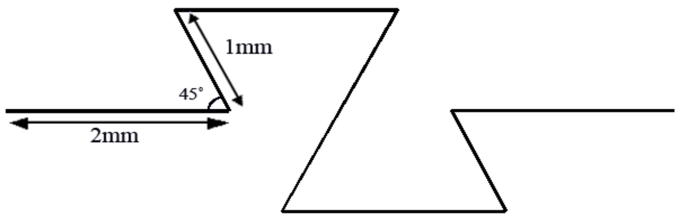


Fig. 1: Proposed generator

By replacing each straight segment at the proposed generator with other the same shape, we get a new shape which is second iteration of the proposed generator.

The proposed design is based on a loaded 2nd iteration of the new generator to a wire monopole antenna. The length of monopole is 1.6cm and wire diameter is 1mm. Therefore, the proposed structure has a compact dimensions of 16×6 mm².

The structure of this fractal monopole antenna is shown in figure 2.

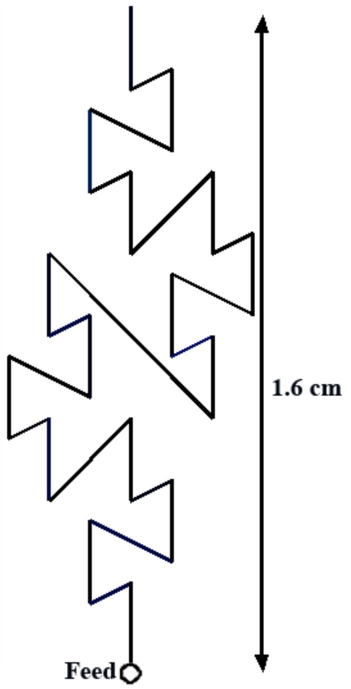


Fig. 2: Antenna structure

According to the simulated VSWR, this is a 40GHz super wideband antenna which is applied in 11-52GHz frequency range with VSWR<2 and can be easily matched with 50Ω coaxial cable.

Also, figures 4 and 5 present real and imaginary parts of input impedance.

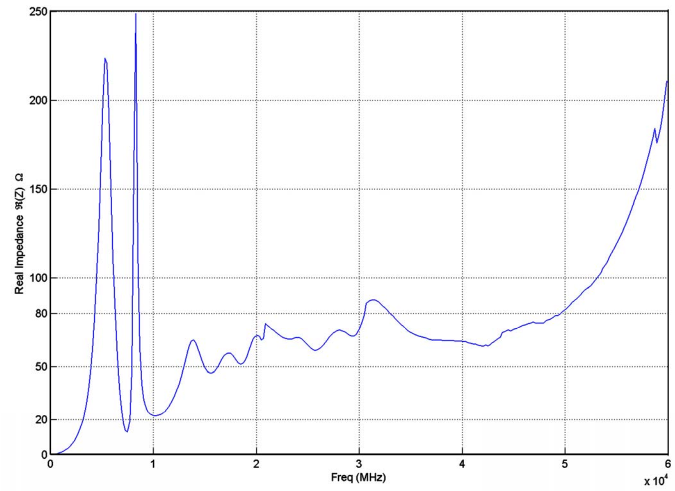


Fig. 4: Real part of input impedance

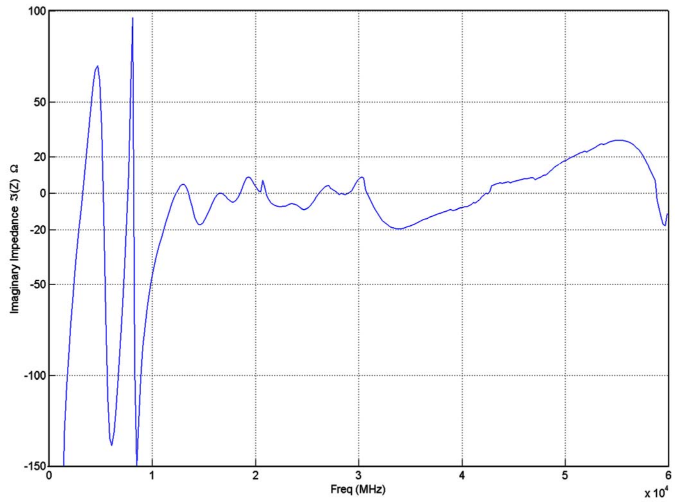


Fig. 5: Imaginary part of input impedance

## III. SIMULATION RESULTS

The MOM (method of moments) is a very powerful technique which can be applied to analysis of complicated geometries such as fractal structures. MOM is used for simulation of this antenna based SuperNEC electromagnetic simulator software. One starts with defining antenna structure for software then, specifying location of feeding. The wire conductivity of all conductors are assumed 5.7E7. Also, the ground plane is assumed perfect. A voltage source is 1 volt and a frequency range is from 10GHz – 60GHz.

Figure 3 presents the simulated VSWR (voltage standing wave ratio) versus frequency.

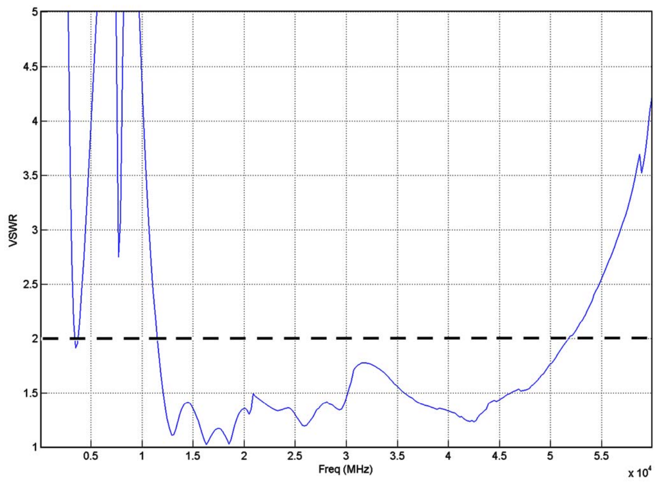


Fig. 3: VSWR of proposed SWB antenna

To study radiation patterns, figure 6 presents radiation patterns in five frequencies, including 11GHz, 20GHz, 30GHz, 40GHz, and 50GHz at XY, XZ and YZ planes.

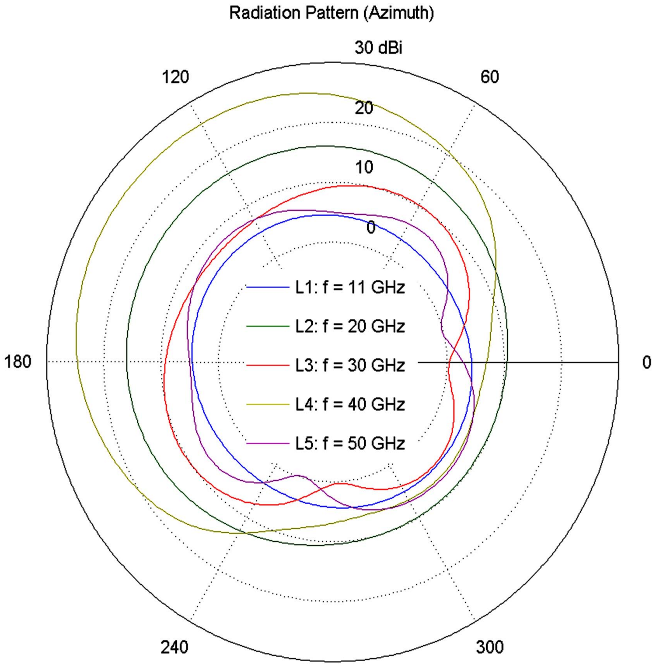


Fig. 6.a: Radiation pattern (XY plane)

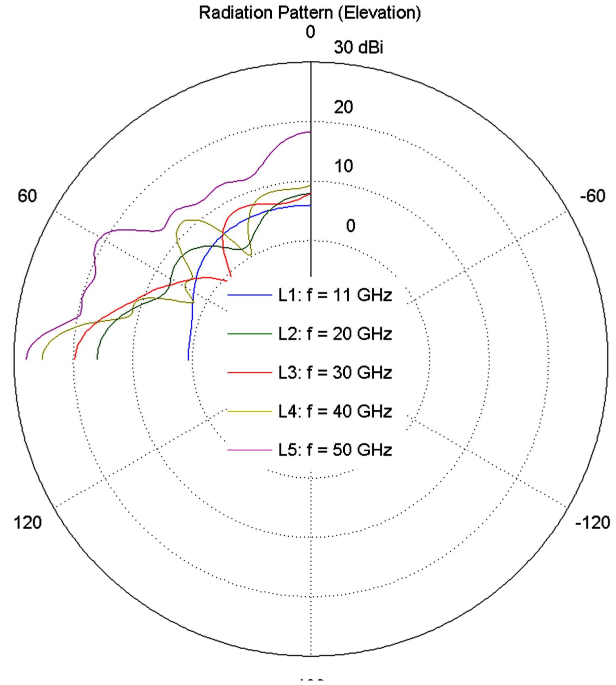


Fig. 6.c: Radiation pattern (YZ plane)

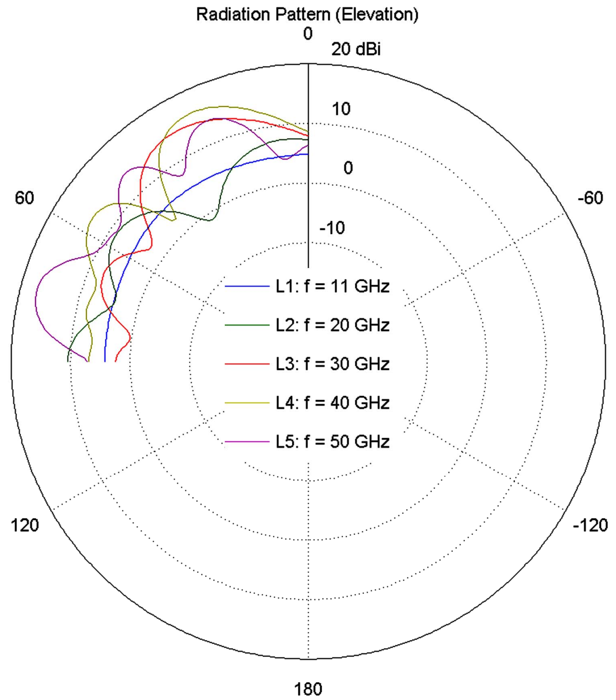


Fig. 6.b: Radiation pattern (XZ plane)

## IV. CONCLUSIONS

Using fractal geometry, we can achieve compact and multi-band antennas. Fractal geometries miniaturize antenna elements and increase bandwidth and effective radiation of antennas.

The proposed design is a loaded 2nd iteration of a new fractal geometry to a wire monopole antenna.

The simulated results directed by the SuperNEC electromagnetic simulator. Due to the simulation results, the proposed design is a super wideband antenna which is applied in frequencies between 11 - 52GHz.

This super wideband antenna is compact, simple to design and easy to fabricate.

## REFERENCES

[1] J.P. Gianvittorio , " Fractals , MEMS , and FSS Electromagnetic Devices Miniaturization and Multiple Resonances " Dissertation, University of California, Los Angeles 2003.

[2] D. H. Werner and S. Ganguly, "An overview of fractal antenna engineering research," IEEE Antenna and Propagation Magazine, vol. 45, pp. 38-57, Feb 2003.

[3] K. J. Vinoy, "Fractal Shaped Antenna Elements for Wide- and Multi – Band Wireless Applications" Thesis , Pennsylvania , Aug. 2002.

[4] J. P. Gianvittorio and Yahya Rahmat Samii, "Fractal Antennas: A Novel antenna Miniaturization Technique and Applications" IEEE Antenna and Propagation Magazine, vol. 44 no.1, Feb 2002.

[5] D. H. Werner, and Raj Mittra, "Frontiers in Electromagnetics ", New York: IEEE Press 2000

[6] C. Puente, J. Romeu, R. Pous, J. Ramis and A. Hijazo, "Small but Long Koch Fractal Monopole" Electronics Letters,1998.

[7] N. Cohen , " Fractal Antenna Application in Wireless Telecommunications " Proceedings of Electronics Industries Forum of New England, pp. 43-49, 1997.

[8] J. Gouyet, "Physics and Fractal Structures" New York: Springer, 1996.

[9] K. J. Falconer, “Fractal Geometry: Mathematical Foundations and Applications” New York: John Wiley & Sons, 1990.
[10] A. Azari, and J. Rowhani, “Ultra Wideband Fractal Microstrip Antenna Design” Progress In Electromagnetics Research C,vol. 2,7-12,2008.
[11] A. Azari, “Super Wideband Fractal Antenna Design” IEEE MAPE 2009, Beijing, CHINA
[12] A. Azari, and J. Rowhani, “Ultra Wideband Fractal Antenna Design” IASTED ARP 2008 Maryland, USA