MODIFIED FRACTAL KOCH CURVE ANTENNA STUDY

Boncho G. Bonev

Technical University of Sofia
8 Kliment Ohridski Blvd., 1700 Sofia, Bulgaria
Tel. +35929652870; E-mail: bbonev@tu-sofia.bg

Abstract

Most of recent wireless communications technologies need multi-band and miniaturized antennas. The fractal antennas advantages fit these challenges. Koch curve fractal structure is one that is often used in antenna design, because of its simplicity.

In this work modified fractal antenna that can be used in wireless communication systems is suggested. This antenna is combination of 1st and 2nd iteration Koch curve.

This antenna has been tested and some main characteristic like SWR dependence on frequency for UHF band, resonance frequencies and radiation pattern have been obtained. The comparison with 1st and 2nd iteration Koch curve antennas have been also performed.

1. INTRODUCTION

Communications development in last years defines more and more requirements towards communication devices. The operation of a single device with several technologies (GSM-900, GSM-1800, UMTS etc.), that work in different frequency bands demands usage of antennas working in these bands. Moreover the tendency of devices miniaturization is also referred to its antennas. Therefore in the last decade there is a strong interest in possibilities of fractal designed antennas usage in telecommunication devices. Their characteristics fit these requirements – multiband usage and small size due to their shape [1-5].

In this paper is presented an experimental investigation on fractal monopole antennas, shaped as Koch curve. The modified monopole Koch curve antenna is suggested. It is combination of 1-st and 2-nd iteration of Koch curve and will be called 1.5 iteration in this paper. The standing wave ratio (SWR) dependence on frequency and radiation pattern in H-plane of the suggested antenna and of the 1-st and 2-nd Koch curve monopole antennas are experimentally obtained.

2. KOCH CURVE

Fractals are geometry objects and each part of them consist their small shapes. The Koch curve monopole is one of the first fractal antennas used in communication. Geometrical shape of zero, 1-st and 2-nd iteration of the Koch curve is showed on Figure 1. The 1-st iteration is obtained as the zero one is partitioned into three equal parts and the middle part is replaced with two elements with the same length. This process is reused for each part of this 1-st iteration and in that way is obtained the 2-nd iteration etc. The total length of the Koch curve can be given with equation [6]

$$L = L_0 \left(\frac{4}{3} \right)^n , \qquad (1)$$

where L_0 is the zero iteration length, also called initiator, and n is the iteration number.

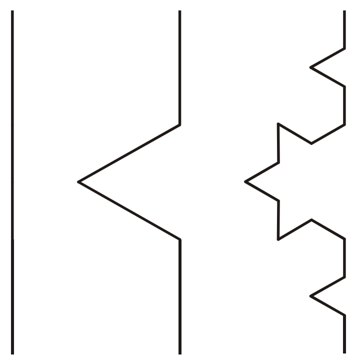

Figure 1. Zero, 1-st and 2-nd iteration of Koch curve

The fractal dimension of the Koch curve is

$$D = \log 4 / \log 3 = 1.2618 . \qquad (2)$$

3. EXPERIMENTAL INVESTIGATION ON KOCH CURVE FRACTAL MONOPOLE ANTENNAS

On Figure 2 are showed the antennas that are object of the experimental study. The antenna in the middle is suggested 1.5 iteration of Koch curve. It is obtained from the 1-st iteration by changing only the two side elements with these of 2-nd iteration. That allows increase of the total length of the antenna and respectively decrease of working frequency bands according to the 1-st iteration, but the shape of this antenna is simpler than the 2-nd order antenna. The total length of the 1.5 iteration is $L_0.\frac{14}{9}$.

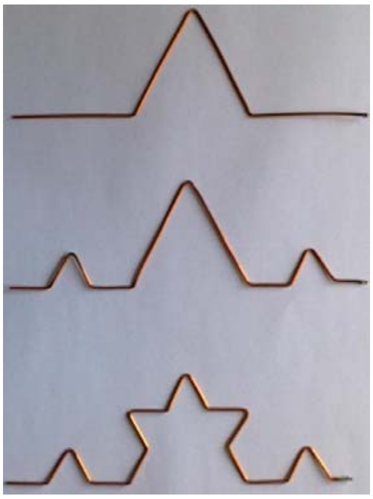

Figure 2. Studied antenna models

3.1. SWR

For obtaining the SWR dependence on frequentcy have been used microwave generator and network analyser. The results are given on Figure 3 – 5, and the resonance frequencies in Table 1. During the experiment the antennas have being placed over conductive surface.

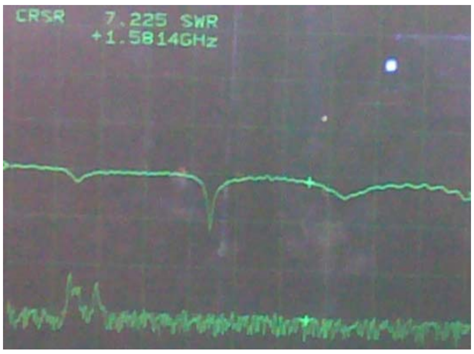

Figure 3. SWR (f) for 1-st iteration

These figures show that when the number of iteration increases the resonance frequency decreases because of bigger length of the antenna model.

The antenna models have 3 resonance frequencies in the frequency band 300 - 2100 MHz. The SWR for the first resonance frequency of all models SWR>2 but it can be improved by using methods described in [7]. The bandwidth (SWR<2) for 2-nd and 3-rd resonance of suggested 1.5 iteration antenna is respectively 32.25 MHz and 77,5 MHz, while for 1-st iteration it is maximum 50 MHz and for 2-nd iteration maximum 56,3 MHz.

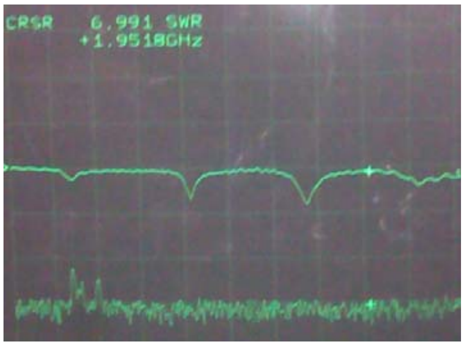

Figure 4. SWR (f) for 1.5 iteration

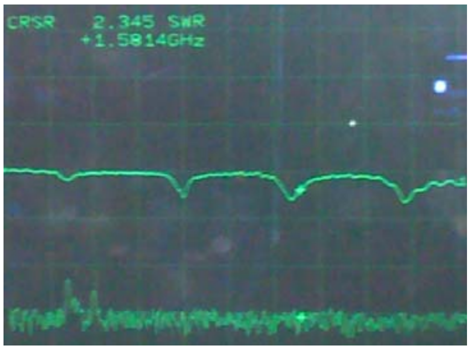

Figure 5. SWR (f) for 2-nd iteration

Table 1. First three resonance frequencies of studied models

1-st iteration	1.5 iteration	2-nd iteration
366 MHz	356.5 MHz	359 MHz
1.069 GHz	1 GHz	966 MHz
1.763 GHz	1.623 GHz	1.544 GHz

3.2. Radiation patterns in H-plane

On Figures 6, 7, 8 are given radiation patterns of the studied models in H-plane.

They were measured in open area. In this measurement two equivalent antennas in the transmitter and in the receiver were used. The investigation was fulfilled for the 2-nd resonance frequency of each antenna model – see Table 1. The antennas were situated in distance of 5 m over conductive surface.

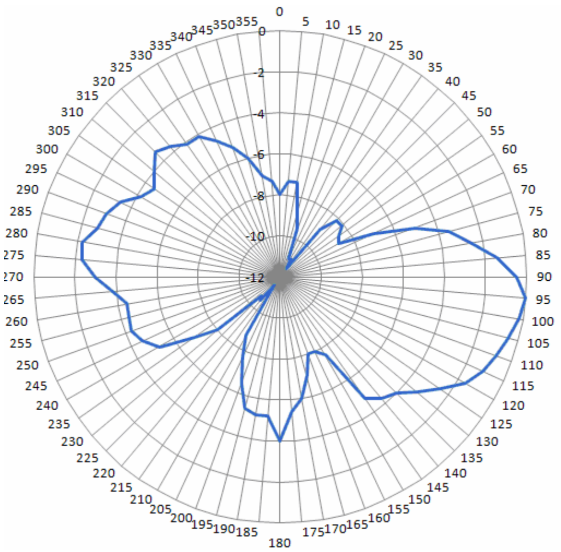

Figure 6. Radiation patern in H-plane for 1-st iteration antenna model

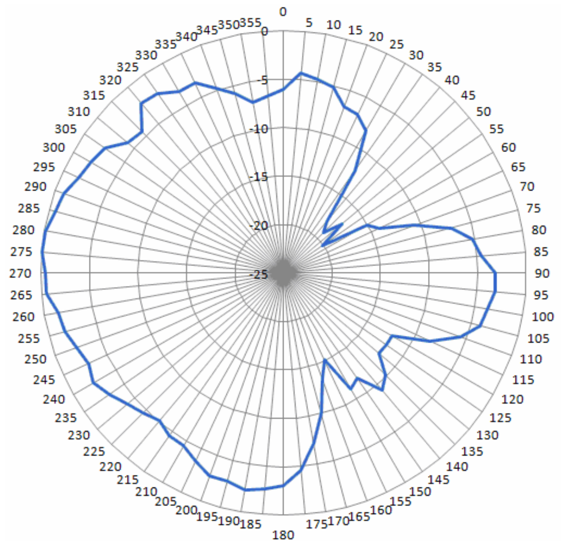

Figure 7. Radiation patern in H-plane for 1.5 iteration antenna model

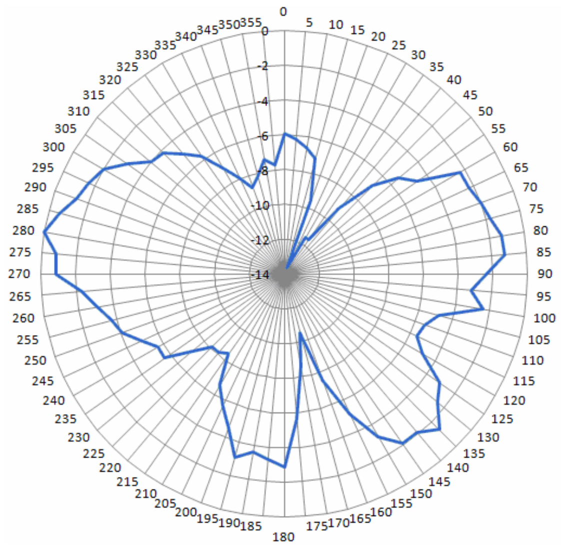

Figure 8. Radiation patern in H-plane for 2-nd iteration antenna model

4. CONCLUSIONS

Maximums of the radiation patterns are approximately in the same directions for all studied models. The radiation patterns have two basic lobes like classical monopole antennas but 2-nd iteration has also some small side lobes.

The radiation pattern of the 1.5 iteration antenna has main lobe that is wider than of other two antennas. That allows this antenna to be used for some radio links that required almost isotropic radiation in given sector for example in point-to-multipoint systems, security systems, observation systems etc. The bandwidth of 1.5 iteration antenna is bigger than of 1-st and 2-nd iteration antennas. That allows this antenna to be used in communication technologies that required wider bandwidth.

5. ACKNOWLEDGMENTS

This work was supported under Project INDECT - "Intelligent Information System Supporting Observation, Searching and Detection for Security of Citizens in Urban Environments."

References

[1] R. S. Aziz, M. A. S. Alkanhal, and A. F. A. Sheta, Multiband Fractal-like antennas, Progress In Electromagnetics Research B, Vol. 29, pp. 339-354, 2011.

[2] Y. Lee, J. Yeo, R. Mittra, S. Ganguly, J. Tenbarge, Fractal and Multiband Communication Antennas, 2003 IEEE Topical Conference on Wireless Communication Technology, pp. 273-274, 2003.

[3] Munish Kumar, Trisha Garg, Antenna Miniaturization using Fractal Antenna and its Design, International Journal of Enterprise Computing and Business Systems, Vol. 1 Issue 2 July 2011, http://www.ijecbs.com.

[4] Kulbir Singh, Vinit Grewal, Rajiv Saxena, Fractal Antennas: A Novel Miniaturization Technique For Wireless Communications, International Journal of Recent Trends in Engineering, Vol 2, No. 5, November 2009.

[5] Anagnostou D., M.T. Chryssomallis, J.C. Lyke, C.G. Christodoulou, Improved multiband performance with self-similar fractal antennas, 2003 IEEE Topical Conference on Wireless Communication Technology, pp. 271-272, 2003.

[6] Karim M.N.A., M.K.A Rahim,. M. Irfan, T. Masri, Fractal Koch curve for UHF band application, 2007. APACE 2007. Asia-Pacific Conference on Applied Electromagnetics, pp. 1-4, Dec. 2007.

[7] Angelov, K., B. Bonev, P. Simeonov, R. Tsochev, Fractal Designed Antenna Matching, ICEST'2011, Nis, Serbia, pp. 675-678, June 2011.