Dielectric Substrate Thickness Impact on Frequency Properties of Monopole Sierpinski Gasket Antenna

Peter Petkov[1], Boncho Bonev[2], Teodora Dimova[3]

Abstract – **In this paper the dielectric substrate width influence on frequency properties of the modified Sierpinski gasket monopole antenna are investigated. Return loss and radiation pattern of antennas with different width of substrate was simulated and analyzed. Increase of the dielectric substrate width lead to decrease of the frequencies bands but also narrow them.**

Keywords – **Dielectric substrate, Monopole Antenna, Sierpinski fractal, Surface waves.**

I. INTRODUCTION

In last years development of telecommunication technologies develops very fast. Therefore more and more requirements towards communication devices are set – operation in several frequency bands and relatively small size. These reasons bring new challenges to antenna design and in the resent years there is a strong interest in fractal-shaped antennas usage in wireless communications. Their characteristics largely correspond to those challenges – multiband usage and relatively small sizes [1-5].

There is also strong interest in modified fractal antennas [1-5]. The most of them are designed as monopole antennas based on Sierpinski fractal. Some authors use modifications of well known fractal structures to obtain needed boundaries of antennas frequency bands. In [1] are proposed modifications based on triangle monopole antenna with trapezoidal slot or slots. These multiband fractal-like antennas operate in several frequency bands and the dimensions of slots allow adjustment of the edges of the bands. In [2] are analyzed similar structures and the antennas designed as Sierpinski fractal in which only the bottom triangle of the fractal is modified by development to the next iteration. In some papers [5] are presented modified Sierpinski fractal antenna with non-equilateral and non-identical triangles. All of authors aim to achieve multiband performance by modification of the fractal structures or some of their parts and to adjust the boundaries of the desired frequency band.

The Sierpinski fractal, antennas because of their complicated shape, can't be manufactured only by metal. They can be performed as metal holding on dielectric substrate. In our previous work [6] were investigated such a structures and very strong depends of their frequency properties on dielectric substrate width has been found. The dielectric substrate changes electromagnetic characteristic of the antenna and increase of its width narrows significantly operation frequency bands.

In this work the dielectric substrate width influence on frequency properties and radiation pattern of the modified Sierpinski gasket monopole antenna are analyzed.

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II. DESIGN AND ANALYSIS

Antenna description

A modified 3-rd generation Sierpinsky Gasket Antenna was designed in order to accommodate 2.4 and 5.5 GHz ISM frequency bands. Antenna is etched on FR4 substrate with 0.2mm substrate thickness and act as monopole over a ground plane (Fig. 1).

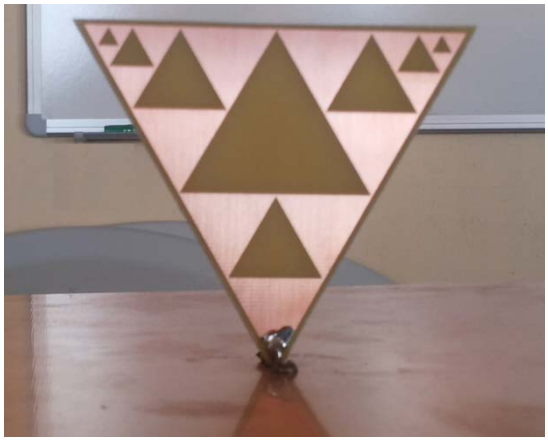

Fig. 1. A photograph of manufactured experimental model.

There is a departure from the strict deterministic fractal shape, made in order to increase the width of the operation bands and to center them on the desired frequencies. This is achieved by use of combination of second and third order fractal notches. The frequency properties of developed antenna are shown on Fig. 2. Antenna shows excellent performance and good agreement between simulated and measured data.

Antenna modifications

In order to research and evaluate the substrate features impact on radiation properties of the Monopole antenna, several models with different substrate thickness have been developed and analyzed. Fig 3. displays the antenna return loss over frequency, with substrate thickness as parameter. It

is obvious that small substrate thicknesses (0.2-0.4mm) has significantly less impact on antenna frequency bandwidth, while use of relatively thick substrates leads to a major decrease in the frequency band of operation.

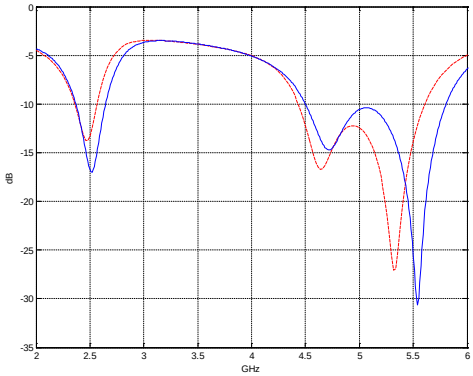

Fig. 2. Return loss of the proposed Modified Fractal Antenna (Soid line – simulated data, Dashed line – measured data).

There is a threshold value (at about 0.8mm) for the given substrate permittivity and frequency of operation, where antenna properties are completely compromised. Surface waves excite and propagate at about this substrate thickness and severely deteriorate the antenna performances. The degradation is noticeable not only in the antenna return loss, but also in the antenna patterns due to fields radiated from the fringing edges (Figs. 4 and 5).

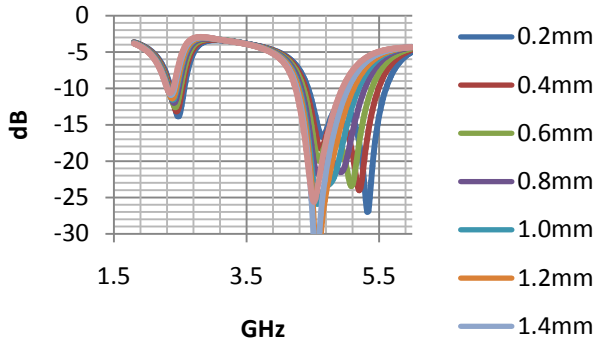

Fig. 3. Return loss of the proposed Modified Fractal Antenna with different substrate thicknesses

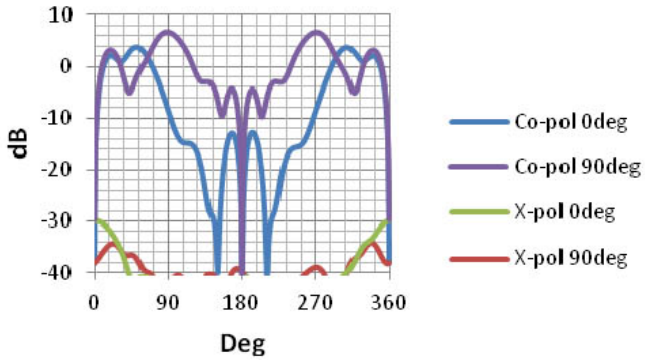

Fig. 4. Antenna radiation pattern (0.2mm substrate thickness)

In the case of 0.2mm substrate thickness, the proposed antenna has an undisturbed omni-directional pattern, with a very low cross polarization components (Fig. 4). On other hand, the thick (1.6mm) substrate antenna has perturbed pattern with radiation maximum almost parallel to the substrate surface. The later leads to conclusion that a surface wave has been excited which leaks out of the substrate.

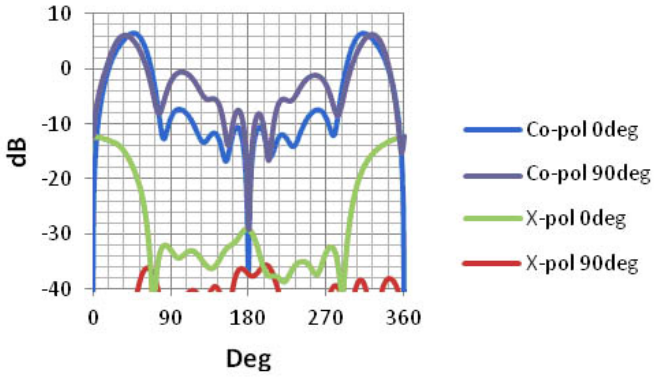

Fig. 5. Antenna radiation pattern (1.6mm substrate thickness)

Cross-polarization component is also increased and prevents the antenna from normal mode of operation. This effect can be prevented by use of thinner substrates or by use of substrate with lower dielectric permittivity.

III. Conclusion

In this paper a modified Sierpinski gasket antenna has been developed and examined. It has been concluded that substrate thickness has a significant impact on antenna performance and must have held into the account when similar antennas are designed and analyzed.

References

[1] R. Aziz, M. Alkanhal, and A. Sheta, “Multiband Fractal-like Antennas”, Progress in Electromagnetics Research B, vol. 29, pp. 339-354, 2011.

[2] W. Krzysztofik, “Modified Sierpinski Fractal Monopole for ISM-Band Handset Aplications”, IEEE Transactions on Antennas and Propagation, Vol. 57, No. 3, pp.606-615, March 2009.

[3] K. Han, F. Harackiewicz, “Modified Multiband Sierpinski Gasket Monopole Antennas”, IEEE Antennas and Propagation Society International Symposium, Vol. 4, pp. 238-241, June 2003.

[4] G. Tsachtsiris, C. Soras, M. Karaboikis and V. Makios, “A Modified Sierpinski Gasket Monopole Antenna for a PCMCIA Card Operating in the 2.4 and 5.15 GHz ISM Bands”, Proceedings of the IASTED International Conference on Advances in Communications, pp. 212-215, Rhodes, July 2001.

[5] Y. Choukiker, and S. Behera, “CPW-Fed Compact Multiband Sierpinski Triangle Antenna”, 2010 Annual IEEE Indian Conference, pp. 1-3, Calcuta, December 2010.

[6] P. Petkov, B. Bonev, “Analysis of a Modified Sierpinski Gasket Antenna for Wi-Fi Aplications”, Proc. of RADIOELEKTRONIKA’2014, Bratislava, Slovak Republic, ISBN 978-1-4799-3714-1, 15-16 April 2014.