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Design the planar Sierpinski-gasket conical monopole antenna

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Abstract
Planar Sierpinski monopole exhibits a multiband behavior, but its parameters in operation frequency bands are not optimal. By mapping the Sierpinski monopole on a conical surface, a symmetrical three-dimensional (3-D) structure is obtained. In this way, a larger bandwidth and a better radiation pattern is achieved. The symmetrical 3D Sierpinski-based monopole is an original contribution of this paper.
In the paper, different versions of the conical Sierpinskibased monopole are designed, and results of simulations performed in CST Microwave Studio are mutually compared. Then, the simulated versions of the conical monopole are optimized according to specified criteria. The optimized conical Sierpinski-based monopole is manufactured and its properties are experimentally verified. Results of measuring the Sierpinski-based conical monopole antenna are published here for the first time.

Keywords: Sierpinski monopole, multi-band antenna, conformal antenna, fractals, conical monopole

Introduction

In today's communication devices, multi-band antennas play a relevant role. The multi-band behavior of the antenna can be obtained by applying self-similarities of fractals [1]. The number of operation frequency bands depends on the number of fractal iterations then [2].

In this paper, ways of converting a planar version of the Sierpinski monopole to the conformal, conical antenna are discussed. Following the described way, two versions of the conical monopoles can be created. The designed antennas are modeled in CST Microwave Studio and their properties are mutually compared. The first kind of the conical monopole antenna was published in [3], and the second one is an original contribution of this paper.

The designed conical Sierpinski-based monopole is optimized using particle swarm optimization (PSO) and the Nelder-Mead simplex algorithm to reach a proper impedance matching in specified frequency bands. The optimized antenna is measured and results are compared with simulations.

In Section 2, properties of a planar Sierpinski monopole and the modified gasket monopole antenna are briefly reviewed [4]. In Section 3, planar versions of antennas are projected to the conical surface [4]. Section 4 deals with the optimization of designed antennas, and Section 5 presents experimental results. Section 6 concludes the paper.

Planar Sierpinski Monopole

The planar Sierpinski monopole of the third order (Fig. 1) is created by 3 self-similar elements. The antenna is attached to the perfectly electrically conducting ground plane. At the antenna input, the SMA connector is assumed [4].

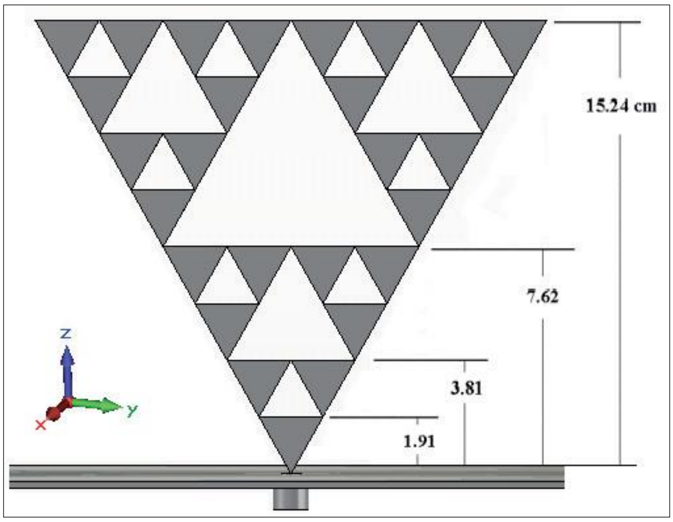

Fig 1: Sierpinski monopole.

In frequency response of the return loss (Fig. 2), the multi-band behavior can be observed (the first band reaches $|S_{11}|$ = –9.74 dB, the next three bands exhibiting $|S_{11}| < -10$ dB for the reference impedance 50 Ω) [4].

The lowest operation frequency is determined by the dimensions of the basic bowtie monopole. The higher operation frequencies are determined both by the basic bowtie structure and the triangular slots [4].

In the left-hand part of Table. 1, magnitudes of S11 at the input of the planar Sierpinski monopole at the operation frequencies are summarized. Obviously, S11 does not reach the optimal values and bandwidths are narrow.

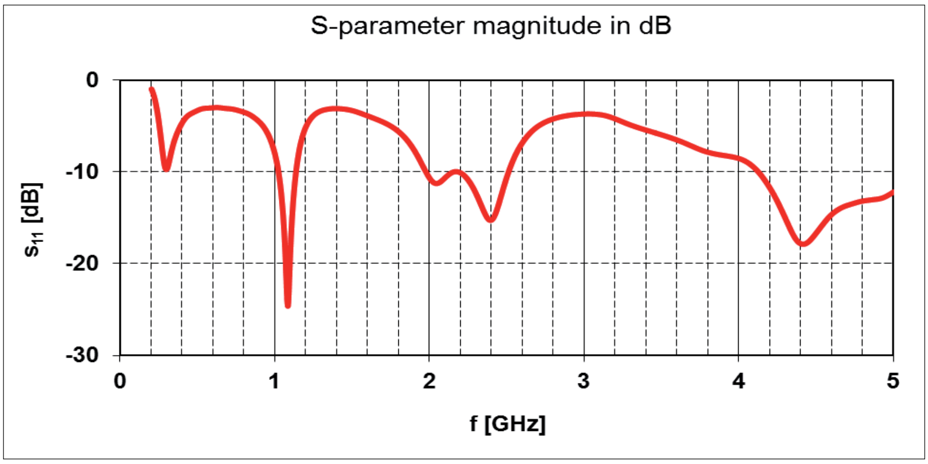

Fig 2: Frequency response of the planar Sierpinski monopole return loss.

In order to improve the impedance matching, the concept of the modified gasket monopole antenna (Fig. 3) can be adopted [3]. The vertical distance of the slot from the ground plane equals to the height of the smallest triangles of the Sierpinski structure [4].

Table 1: Return loss of the conventional Sierpinski monopole (left) and the modified gasket monopole (right) at operation frequencies. Planar structure assumed.

Sierpinski monopole			Modified gasket monopole		
f [GHz]	S_{11} [dB]	BW [MHz]	*f* [GHz]	S_{11} [dB]	BW [MHz]
0.29	–9.74	71	0.31	–8.17	145
1.08	–24.63	25	1.18	–21.34	51
2.39	–15.28	180	2.66	–17.65	126
4.41	–17.89	243	4.63	–33.33	48

Frequency response of S_{11} of the modified gasket monopole is depicted in Fig. 4. In the right-hand part of Tab. 1, magnitudes of S_{11} at operation frequencies are compared with the values of the Sierpinski monopole. The responses are similar.

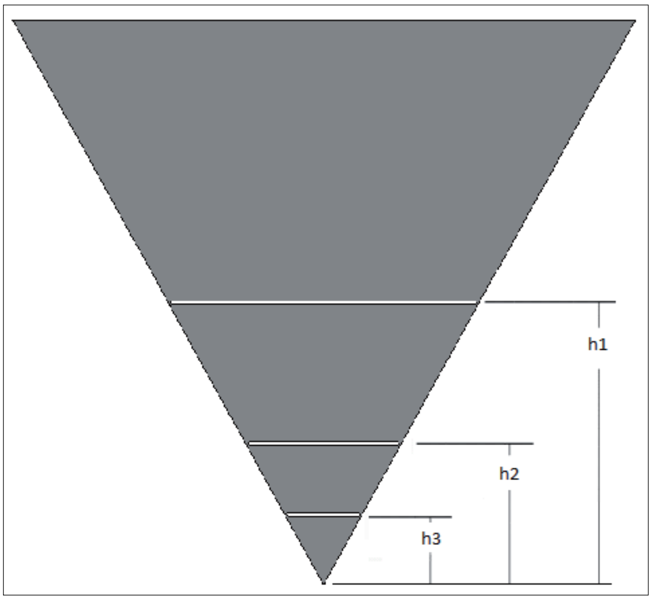

Fig 3: Planar gasket monopole antenna.

Radiation patterns of both planar antennas exhibit asymmetries caused by their asymmetrical geometry. In order to obtain the omni-directional pattern in the horizontal plane, geometries of planar antennas are projected into the conical surface [4].

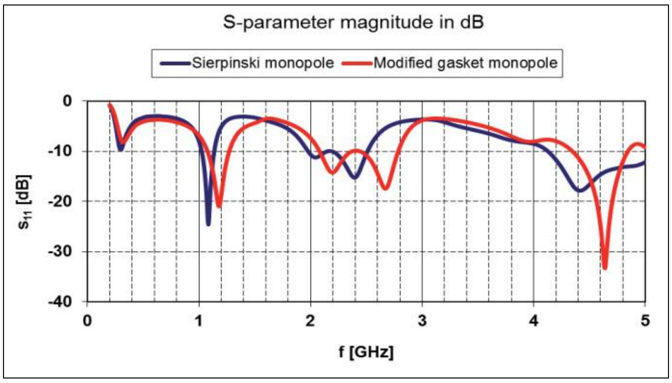

Fig 4: Frequency response of return loss of the planar Sierpinski monopole (blue) and the gasket monopole antenna (red). Planar structures.

Conical Sierpinski-Based Monopole

In order to improve the symmetry of the radiation and to make the bandwidth wider, the planar structure is mapped [3] to the conical surface (Fig. 5).

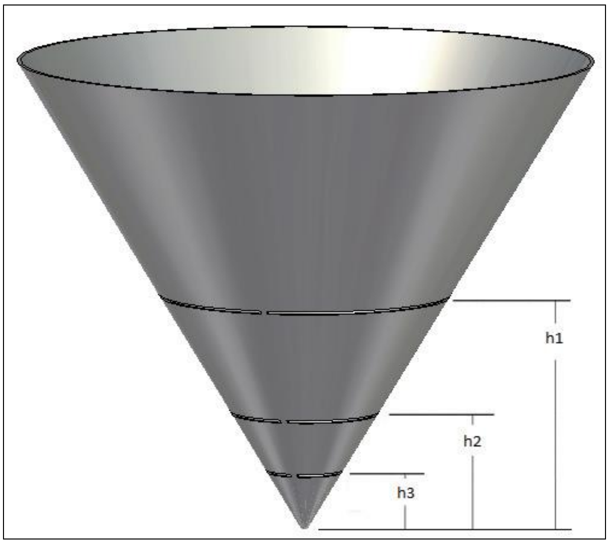

Fig 5: Conical gasket monopole antenna.

Thanks to the conical shape, the omni-directional radiation and wider operation bandwidth are reached [3]. Heights of segments of the conical gasket monopole are identical with lengths of segments of the planar antenna.

Frequency response of the reflection coefficient at the antenna input S11 is depicted in Fig. 7. Magnitudes of the reflection coefficient in operation frequency bands are summarized in the right part of Table. 2.

Next, the layout of the planar Sierpinski monopole was mapped to the conical surface (Fig. 6). The mapping resulted in an asymmetrical geometry. Heights of triangles of the conical antenna are identical with heights of triangles of the planar Sierpinski monopole.

The frequency response of the magnitude of the reflection coefficient S_{11} at the input of the conical Sierpinski- based monopole (Fig. 7) is similar to the characteristics of the planar Sierpinski monopole.

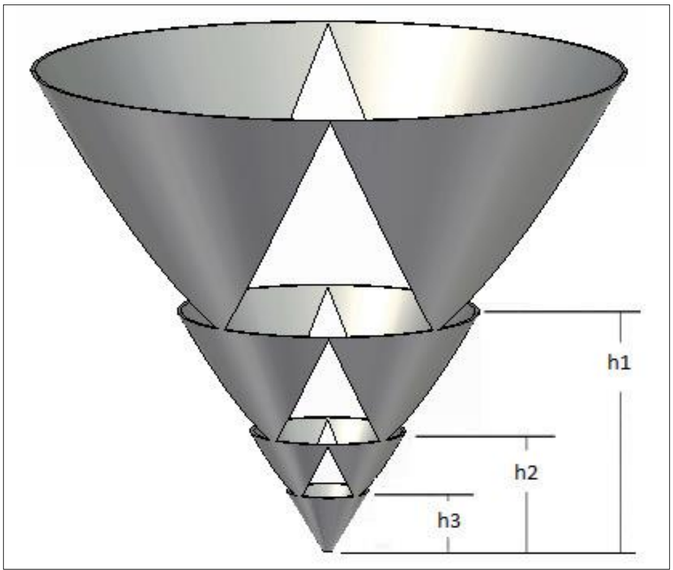

Fig 6: Conical Sierpinski-based monopole.

Values of S_{11} of the conical Sierpinski-based monopole in operation bands are given in the left-hand part of Table. 2. Operation bands of the conical gasket monopole are shifted downwards, and the improvement of bandwidth with lower frequency is visible.

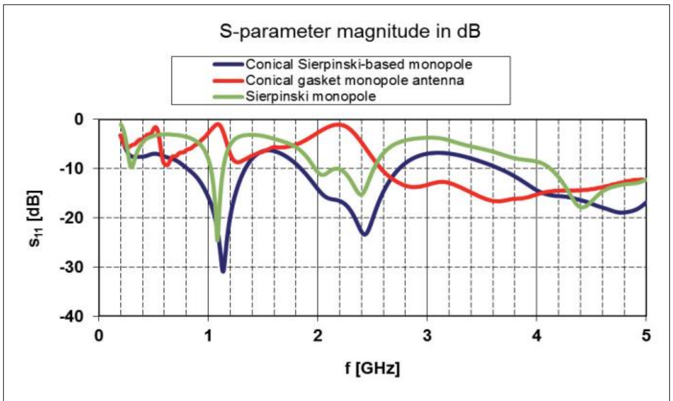

Fig 7: Frequency response of return loss of the conical Sierpinski-based monopole (blue) and the gasket one (red). Conical structures.

Radiation patterns of the conical gasket monopole are depicted. Here, the power improvement as well as the similarity of the radiation spectrum is obvious. The conical Sierpinski-based monopole produces two beams, similar to a conventional monopole. Due to the symmetry of the structure in the vertical plane, an omnidirectional radiation character was achieved.

Table 2: Magnitude of S_{11} at the input of the conventional Sierpinski-based monopole (left) and the conical gasket monopole antenna (right) at operation frequencies. Conical structures assumed.

Conical Sierpinski-based monopole			Conical gasget monopole antenna		
f [GHz]	S_{11} [dB]	BW [MHz]	*f* [GHz]	S_{11} [dB]	BW [MHz]
0.38	–7.57..	-	0.24	–6.94..	-
1.13	–31.01..	76	0.60	–10.21..	231
2.42	–23.37..	16	1.25	–8.84..	368
4.74	–18.97..	476	2.87	–13.21..	-

Conclusions

Conical fractal antennas were derived from the planar Sierpinski structure. By mapping the planar layout to the conical surface, better omni-directional radiation and wider bandwidth were reached.

The conical gasket monopole exhibits the shift of operating bands and the impedance matching is worse compared to the conical Sierpinski-based monopole. The bandwidth of both the antennas was increased.

Radiation properties of both the conical monopoles were improved. Moreover, resonances in similar operation frequency bands were reached.

Operation bands were tuned for the conical Sierpinski-based monopole, and the resultant antenna was fabricated. The measured results slightly differ from the simulations.

The conical Sierpinski-based monopole exhibits good impedance matching and good radiation properties. On the other hand, the size of this monopole is large and the manufacturing is complicated.

References

1. Mandelbrot BB. The Fractal Geometry of Nature. New York: W.H. Freeman and Company, 1982.
2. Puente C, Romeu J, Pous R, Cardama A. On the behavior of the Sierpinski multiband fractal antenna. IEEE Transactions on Antennas and Propagation. 1998; 46(4):517-524.
3. Best SR. A multiband conical monopole antenna derived from a modified Sierpinski gasket. IEEE Antennas and Wireless Propagation Letters. 2003; 2:205-207.
4. Všetula P, Raida Z. Sierpinski conical monopole antennas. In Proceedings of the 15th Conference on Microwave Techniques COMITE. Brno (Czech Republic), 2010, 55-57.