Self-similar Surface Current Distribution on Fractal Sierpinski Antenna Verified with Infra-red Thermograms

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Abstract.-: **Experimental verification of the Fractal Sierpinski Antenna surface current distribution is presented. Measured data from an infra-red camera agree with numerical data showing a self-similar behavior in the current density distribution over the fractal antenna surface. This result gives a better insight on the multiband behavior of the fractal-shape antenna.**

1. Introduction

New experimental results on the Fractal Sierpinski Antenna behavior are presented in this paper. This new experimental dates will help to a better understanding of the fractal-shape antenna performance which has been described in previous publications [1-3]. Multiband behavior is the main characteristic associated to the antenna. The multiband characteristic can be directly associated to the self-similarity property that characterizes the fractal shape geometry. The multiband behavior has been basically described through the antenna main input parameters and radiation patterns [1-3], both simulated and measured. In this work, a new experimental-tool based on infrared thermograms [4] has been used for the verification of the self-similar behavior in the antenna surface current distribution. These new measures will contribute with a new insight on the multiband behavior of the fractal Sierpinski antenna.

2. Design

The fractal-shape antenna analyzed is based on the equilateral Sierpinski triangle, generated up to a five level iteration. The fractal body contents several reduced copies of the global structure, where five different scale

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factors have been applied. The scale reduction factor associated to each fractal iteration level is defined by the log-period that characterizes the fractal geometry. In the Sierpinski triangle the log-period (δ) takes value 2. Therefore, the following heights can be associated to the different fractal levels as it is shown in Fig.1: h, $h/2$, $h/2^2$, $h/2^3$, $h/2^4$, where h is the total antenna height.

An electromagnetic antenna behavior can be explained through the surface current density distribution of the antenna. In this sense, the multiband behavior of the fractal Sierpinski antenna has been explained through the existence of an active region [3], understood as the major density current distribution that has the biggest contribution to the radiation phenomenon. A multiband antenna is characterized for showing the same parameters (impedance and radiation pattern) in several different bands. It can be suggested that this behavior can be reached by self-scaling the active region for each frequency range.

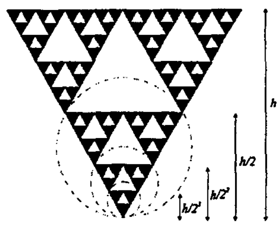

Figure 1. Fractal Sierpinski antenna mask (5 iteration, 60° flare angle). Second, third and fourth band are dashed-line circled.

The surface current distribution in the Fractal Sierpinski antenna were simulated applying an algorithm based on the Finite Difference Time Division method (FDTD) [5]. In Fig.2 the magnitude of the simulated current distribution is shown. It should be stressed that for each operating band in the Sierpinski antenna, the active region is self-scaled in a factor of 2 each time the operating wavelength is reduced by the same factor. The active region tends to concentrate towards the antenna apex feeding point. It is also interesting to notice how the surface current distribution keeps similar in the active region through the different operating bands, as it can be observed from the zoom plot of the active region in the Fig.2 right column.

3. Results

In order to verify the behavior of the antenna before mentioned, three 60° Sierpinski antennas have been designed printed on fiberglass, whose losses allow to acquire thermic images. All of the antennas work at the same frequency (as a microwave source we use a magnetron at 2.45 GHz), although this frequency has been associated with a different band in every antenna, scaling properly their size. Measured frequency bands were the 2nd for the smaller antenna (h_2=6 cm), the 3rd for the medium-size antenna (h_3=12 cm) and the 4th for the larger one (h_4=22 cm). First band was not measured due to the small dimension that the antenna would have and the

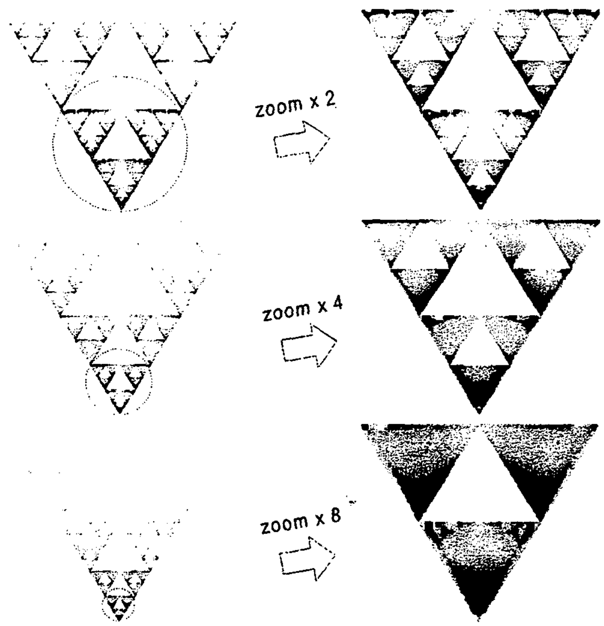

Figure 2: Magnitude of the current density distribution (vertical component) over the Sierpinski antenna surface (FDTD simulation), for the different operating bands, [3], [4].

high resolution that the infrared camera would require in such a case. Fifth band was not measured due to the large antenna needed.

In Fig. 3 thermografic images obtained for the three bands are shown. It is interesting to observe that active region, the shining zone of the image, contracts upon increasing the operating band. When the antenna operates at second band, currents concentrate in the lower half of the structure and

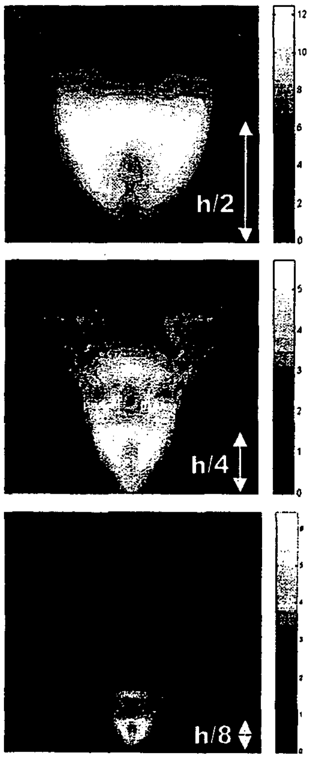

Figure 3: Temperature elevation on the antenna surface measured in the 2^{nd}, 3^{rd} and 4^{th} operating bands using an IR camera.

height of the active region is approximately $h_2/2$. For the antenna operating at third band the active region concentrates in a triangle of height $h_3/4$, while for the antenna at fourth band the concentration takes place in a triangle of height $h_4/8$ maintaining the same aspect ratio to the wavelength.

4. Conclusion

Dimension of the active region of the Sierpinski antennas measured with an infrared camera verify qualitatively the self-similar behavior of the current distribution.

5. Acknowledgements

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6. References

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