Variations on the Fractal Sierpinski Antenna Flare Angle

C.PUENTE*, M.NAVARRO, J.ROMEU, R.POUS.
ELECTROMAGNETICS & PHOTONICS ENGINEERING GROUP (EEF)
DEPT. TSC, UNIVERSITAT POLITÈCNICA DE CATALUNYA,
c/Gran Capità s/n, modul D3 Campus Nord, 08034 Barcelona.
puente@tsc.upc.es, Tel:34-3-4017210, Fax:34-3-4017232

Abstract.-:**A further investigation on the fractal multiband Sierpinski Antenna is introduced here. It is shown that a variation on the antenna's flare angle is translated into a shift of the operating bands, as well as into a change in the impedance level and radiation patterns. The contribution of those variations to the truncation effect is outlined.**

1. *Introduction.-* The fractal Sierpinski antenna based on an equilateral triangle generator [5] was the first reported example of a multiband fractal antenna [1]-[7]. In this work, a new degree of freedom to the antenna design is introduced: the variation on the antenna flare angle. Experimental results are shown to describe the variations on the impedance levels and absolute band positions introduced when changing the flare angle.

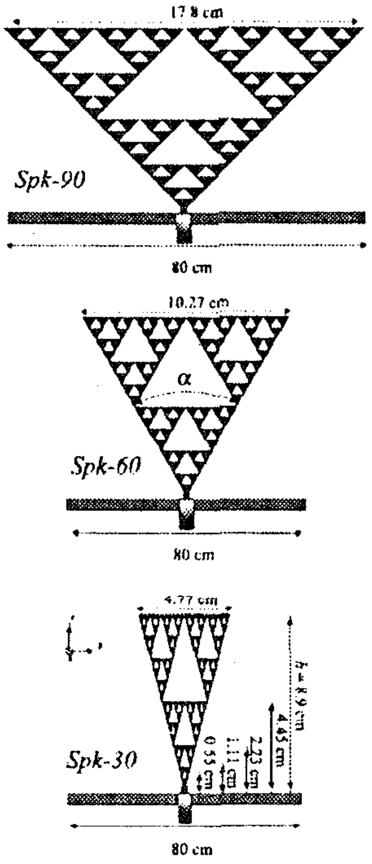

Fig.1 The SPK90 (top), SPK60(center), SPK30(bottom) Sierpinski fractal antennas.

Basically it is shown that broader angles shift the operating bands to lower frequencies, which can be useful to reduce the antenna height. When the angle is made too narrow the multiband behavior is broken and the antenna approaches the behavior of a classical monopole antenna. This is basically due to the truncation effect.

2. *Input Parameters.-* Brown & Woodward described in [8] the input impedance behavior of triangular and conical antennas. Basically, their experimental results evinced that the input resistance and reactance variations were smoother when opening the flare angle. A similar performance was observed on the triangular antennas, although in this case the variations became stronger with respect to the conical one.

Since the Sierpinski antenna has an overall triangular shape, it appears natural to investigate whether those effects on the performance of triangular antennas are translated into the behavior of the fractal one. Therefore, the SPK-90, SPK-60, y SPK-30 antennas (Fig.1) were constructed by following

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the same procedure as described in [7]. The feeding flare angles were, respectively ☞=90°, ☞=60° y ☞=30°.

The plots in Fig. 2 describe the input parameters (input reflection coefficient relative to 50♦⊟ input resistance and reactance) for the three antennas as a function of frequency. In general, it can be stated that:

1) The behavior of the three antennas is basically log-periodic, being the log-period δ=2, which is precisely the scale factor that relates the several fractal iterations in the antenna body.
2) The number of bands or log-periods (5) matches the number of fractal iterations as described in [1].
3) Broader flare angles introduce a shift on the resonant frequencies toward longer wavelengths.
4) The variations on the impedance plots are stronger for the narrower antenna, at least at the first band. This result is comparable to the triangular antenna behavior described in [8].
5) The impedance minimums are reduced at odd resonances are reduced for broader angles, which changes the matching levels with respect to 50♦.

It should be stressed that the multiband behavior of the antennas must be related to its fractal shape, as it is extensively discussed in [6]. The absolute shift on the operating band position (not its relative spacing) with respect to the first version of the antenna (SPK 60), must be related to the size of the isosceles triangle twin edges. Basically, the behavior of these antennas can be modeled with currents propagating along the antenna edges as it is described in [6] and will be explained somewhere else. Therefore, longer edges host longer resonant wavelengths yielding to the shift of the spectral response.

It is interesting to notice that the narrower antenna tends to deviate from the log-periodic behavior. Its input reflection coefficient displays a double match feature which corresponds to a double resonance in the impedance plots. Somehow, the behavior of the SPK30 antenna is closer to that of a classical monopole which holds a clear harmonic (periodic) non multiband behavior.

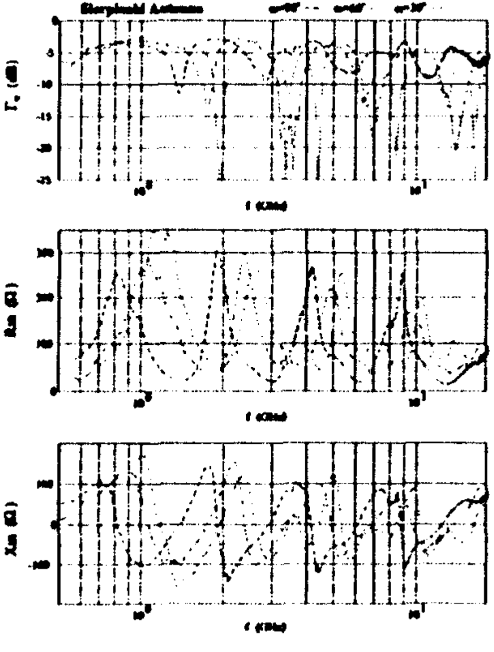

Fig.2 Input parameters for theSPK90 (--), SPK60(-.) and SPK30(-) antennas.

*3. **Radiation Patterns.***- The radiation patterns for the SPK90 and SPK30 antennas (main polarization component along the θ direction, φ=0° cut) are shown in figures 3 and 4 respectively. Those corresponding to the SPK60 antenna are described in [2],[6],[7]. Again, it is observed that the broader angle antenna features a multiband behavior, with a clear pattern similarity among bands. Contrarily, significant deviations among patterns are stated in the SPK30 case; the number of grating lobes tends to increase with frequency, which makes this antenna comparable to the classical monopole. Once more, such a phenomenon must be related to the shorter length of the triangle edges. Somehow, the current active region that characterizes most multifrequency antennas [6] has less room to expand and to become attenuated by the radiation process before reaching the antenna tips. In fractal theory terms, such a truncation effect can be explained by the lack of larger characteristic scales to keep the perfect symmetry of the ideal fractal set.

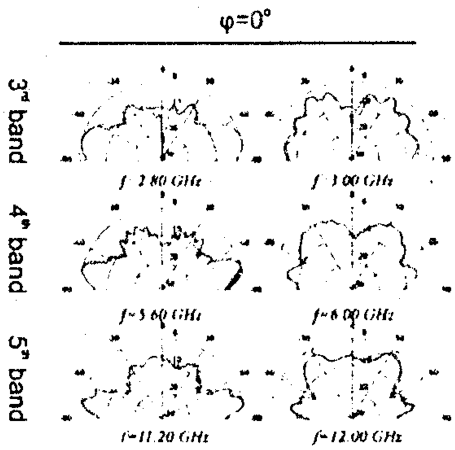

Fig.3 Radiation pattern (φ=90°, E_θ component) for the SPK90 antenna.

This should not be taken as a basis to argue that fractal antennas are not multiband antennas; the suitability of fractals to become multiband antennas directly comes out from the classical scaling property of Maxwell equations [6]. Therefore, one should expect a multiband behavior even for the SPK30 antenna, provided that the antenna size and the number of fractal iterations is made large enough.

*4. **Conclusions.***- The behavior of three Sierpinski fractal antennas has been described through several experimental results. The antennas had the same basic shape with a change on the flare angle. It is shown that such a change introduces significant variations on the antenna input parameters and radiation patterns. Although the designer can freely use those variations for engineering purposes, it must be taken into account that by narrowing the antenna angle a deviation from the multiband behavior is obtained. Except for those cases, where the truncation effect is important, it can be concluded again that fractals can be successfully used to construct simple multiband antennas.

Acknowledgments.- This project has

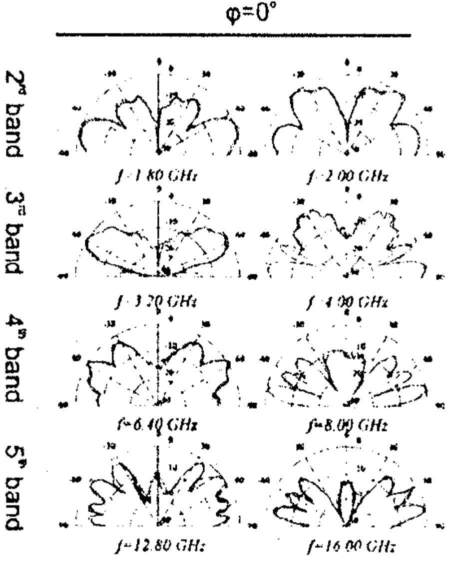

Fig.4. Radiation pattern (φ =90° cut, E_θ component) for the SPK30 antenna.

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