Space-filling Patch Antennas with CPW Feed

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Abstract—In this paper, the performances of some space-filling monopole antennas with coplanar waveguide have been investigated. It may be contended that the bends and corners of these geometries would add to the radiation efficiency of the antenna, thereby improving its gain. Advantage of these configurations is that they lead to multiband conformal antennas. A new version of Gosper curve patch antenna is introduced and its performance has been compared to conventional Gosper curve patch antenna.

1. Introduction

Fractal shaped antennas exhibit some interesting features that stem from their inherent geometrical properties. The self-similarity of certain fractal structures results in a multiband behavior of corresponding fractal antennas and frequency-selective surfaces (FSS) [1, 2].

On the other hand, the high convoluted shape and space-filling properties of certain fractals allow reducing the volume occupied by a resonant element. Theses properties are useful in designing multiband antennas and FSS, and reducing the size of certain antennas.

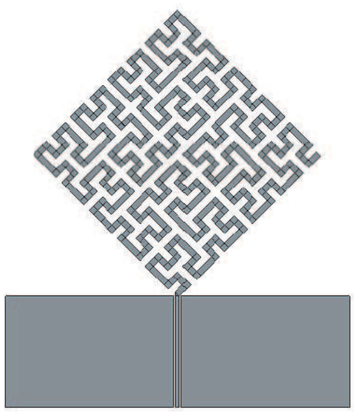

Figure 1: 4^{th} order of Hilbert patch antenna with CPW monopole feed.

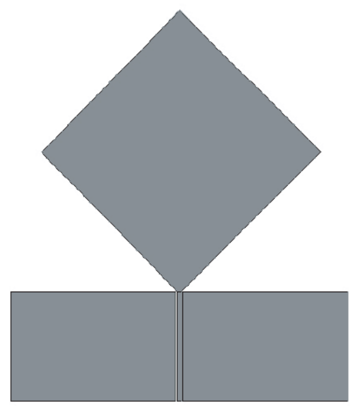

Figure 2: Lozenge shape patch antenna with CPW monopole feed.

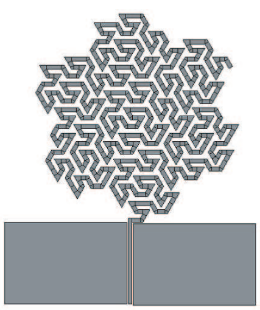

Figure 3: CPW-fed Gosper curve patch antenna.

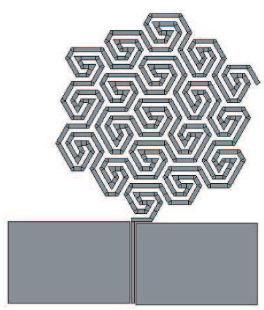

Figure 4: Another version of Gosper curve patch antenna.

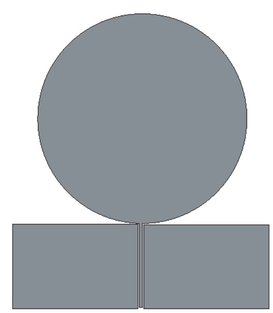

Figure 5: Circular disc CPW-fed monopole antenna.

Microstrip patch Antennas are very popular in many fields as they are low-profile, low weight, robust and cheap. In last years new techniques employing fractal geometries are studied and developed. One of them is the fractalizing of antenna's boundary where new qualitative effect as the higher localized modes appear, that result in directive radiation patterns [3]. Another technique that has been studied in this paper is using space-filling curves as patch radiator.

Space-filling curves map the multi-dimensional space into the one-dimensional space. A space-filling curve acts like a thread that passes through every cell element (or pixel) in the n-dimensional space so that every cell is visited only once. Therefore, the space-filling curve does not self-intersect. Thus, a space-filling curve imposes a linear order of the cells in the n-dimensional space. These geometries have the following properties: Self-Avoidance (as the line segments do not intersect each other), Simplicity (since the curve can be drawn with a single stroke of a pen) and self-similarity [4].

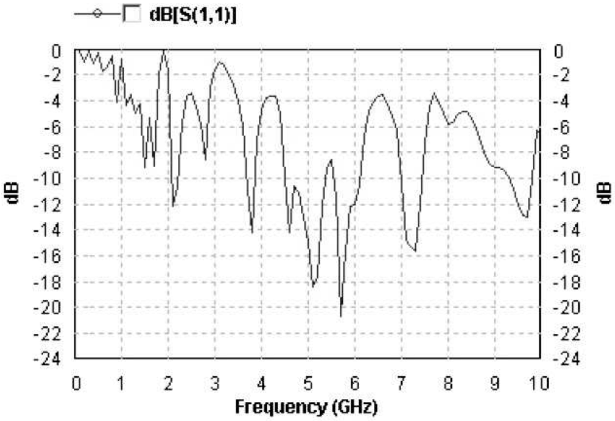

Figure 6: Return loss vs. frequency of antenna configuration in Fig. 1.

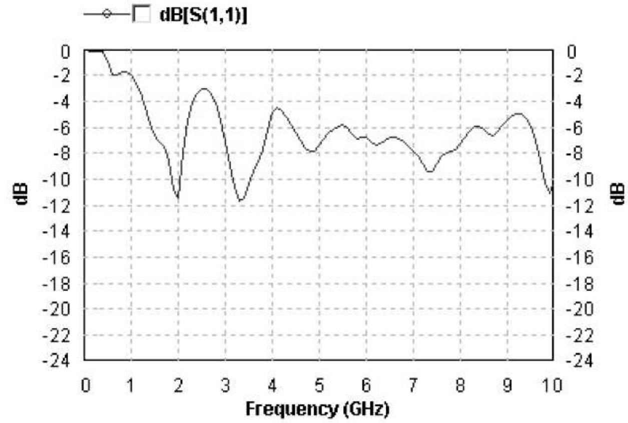

Figure 7: Return loss vs. frequency of antenna configuration in Fig. 2.

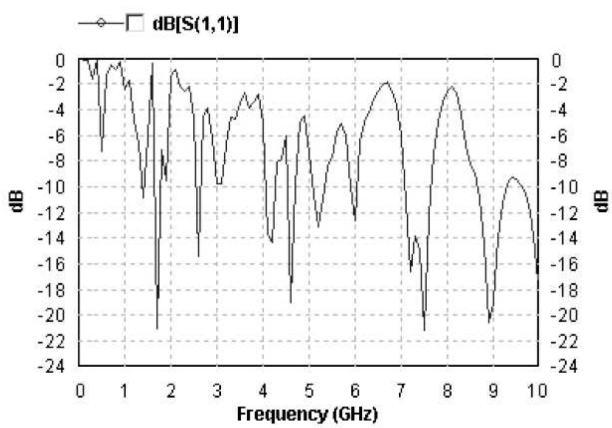

Figure 8: Return loss vs. frequency of antenna configuration in Fig. 3.

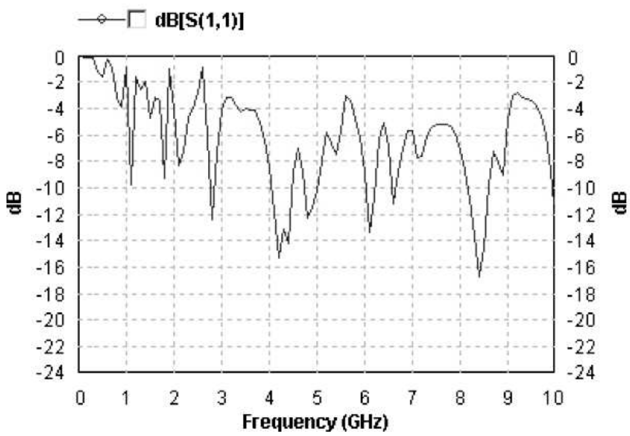

Figure 9: Return loss vs. frequency of antenna configuration in Fig. 4.

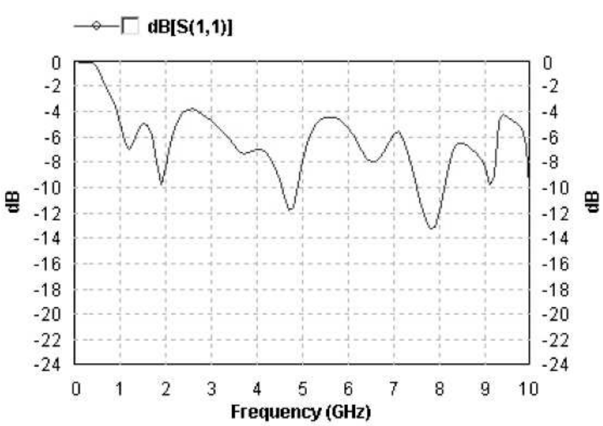

Figure 10: Return loss vs. frequency of antenna configuration in Fig. 5.

There are many types of space-filling curves (SFCs), e. g., the Peano, Hilbert, and Gosper curves, to name a few. They differ from each other in the way they visit and cover the points in space.

In other hand, coplanar waveguide feed is a well-known technique for increasing the bandwidth of patch antennas [5].

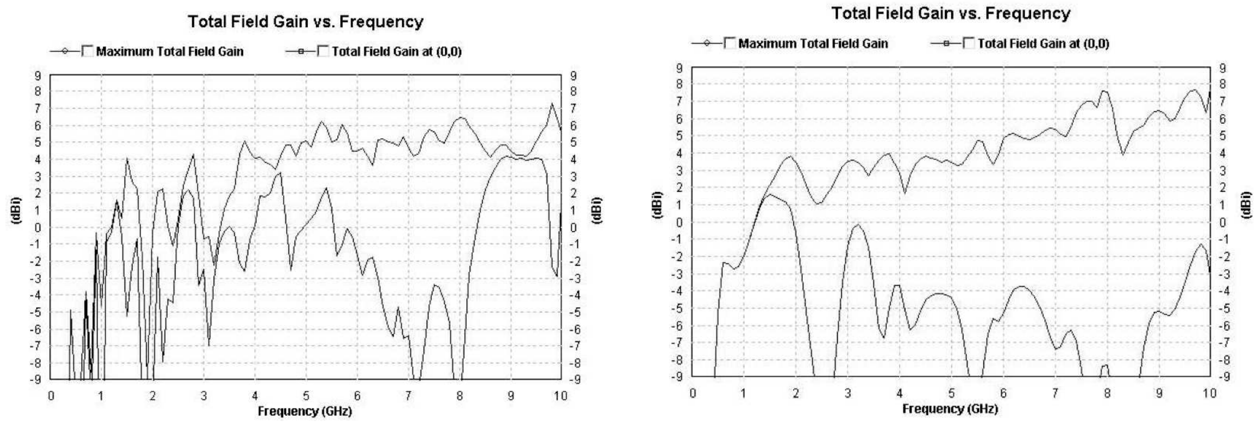

Figure 11: Maximum total field gain and total gain normal to antenna plane vs. frequency of Hilbert curve and lozenge shape antennas (left to right).

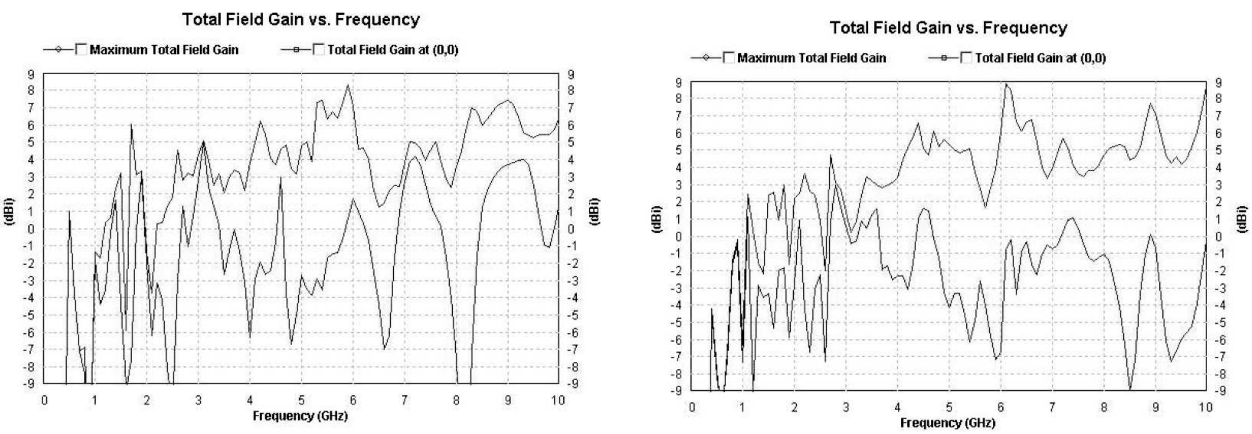

Figure 12: Maximum total field gain and total gain normal to antenna plane vs. frequency of antenna configuration in Fig. 3 and Fig. 4 (left to right).

In this paper, this technique has been imposed on some types of fractal space-filling monopole antennas such as Hilbert curve antenna and Gosper curve antenna.

2. Proposed Antenna Configurations

Schematic of studied structures are shown in Figs. 1–5. These configurations are in a single layer metallic structure. Hilbert curve and Gosper curve radiators are fed through coplanar wave guide monopole feed. For comparison the Euclidean counterparts of these structures have been studied.

Each section of Ground plane has the dimension of 6 cm×4 cm, the width of microstrip feed in every configuration is 1.45 mm while the gap between the strip and coplanar ground plane is 0.1 mm.

The overall height of each space filling curve is assumed to be about 10 cm.

3. Simulation Results

Simulation of the above structures has been done using IE3D MOM-based code. In Figs. 6–10, Return losses versus frequency of these antennas are shown.

Simulation results show that space-filling patch antennas are conformal multiband antennas.

Making a direct relationship between antenna characteristics and geometrical properties of inscribed geometries is not easy. However we can say the results of return loss versus frequency of theses structures show that in same overall dimensions, the space-filling CPW-fed monopole antennas have better performance in input matching characteristics, number of resonant frequencies and bandwidth than their Euclidian counterparts. For instance compare the results of return loss versus frequency of Hilbert curve CPW-fed monopole antenna and lozenge shape CPW-fed monopole antenna (Fig. 6 and Fig. 7) and the results of two versions of Gosper curve CPW-fed monopole antenna and circular disc CPW-fed monopole antenna (Fig. 8 and Fig. 9 with Fig. 10).

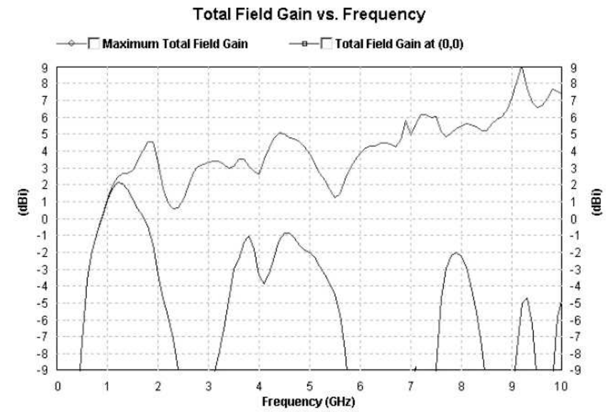

Figure 13: Maximum total field gain and total gain normal to antenna plane vs. frequency of circular monopole antenna (Fig. 5).

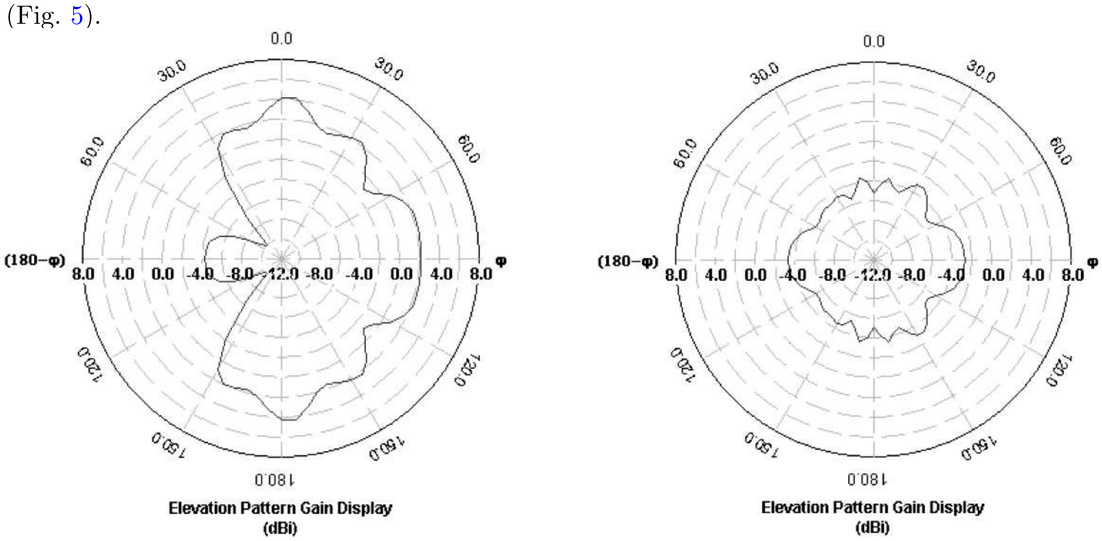

Figure 14: Elevation pattern gain display of Hilbert curve CPW-fed monopole antenna and lozenge shape CPW-fed monopole antenna in 9 GHZ.

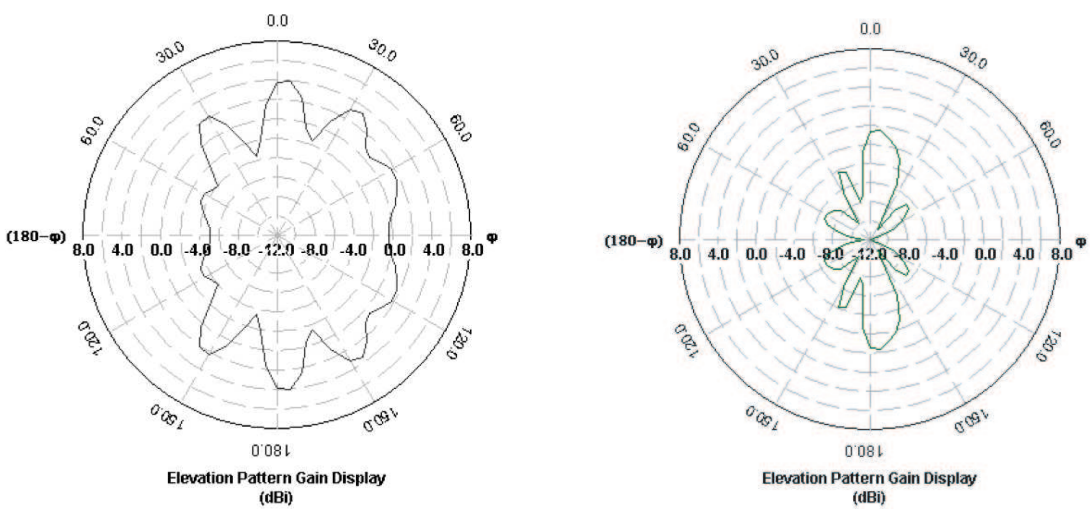

Figure 15: Elevation pattern gain display of two versions of Gosper curve CPW-fed monopole antenna (Fig. 3 and Fig. 4) in 9 GHZ (left to right).

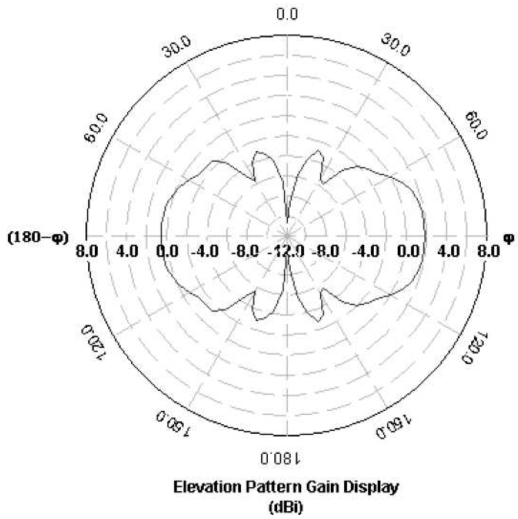

Figure 16: Elevation pattern gain display of circular disc CPW-fed monopole antenna (Fig. 5) in 9 GHz.

Main resonant frequencies of Hilbert curve CPW-fed monopole antenna and lozenge shape CPW-fed monopole antenna are very close together. This can be seen about two version of Gosper curve CPW-fed monopole antenna and circular disc CPW-fed monopole antenna.

The results of maximum total field gain vs. frequency and total gain normal to antenna plane (Z-direction) vs. frequency of these structures are shown in Figs. 11–13. From these results we can see that the space-filling CPW-fed monopole antennas have better gains in the direction perpendicular to antenna plane.

In Figs. 14–16, elevation pattern gain displays of these structures in 9 GHZ are shown. In this frequency all configurations have relatively good input matching characteristics. According to the fact that there is no ground plane except CPW ground plane, elevation pattern display in each structure is bilateral.

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