A New Microstrip Sierpinski Carpet Antenna Using a Circular Pattern With Improved Performance

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Abstract

In this work, we present the two first iterations design of the Sierpinski carpet fractal antenna by using a circular pattern. The proposed antenna is printed on FR4 substrate with a dielectric constant of 4.4. At the second iteration, the studied antenna has a multiband behavior with four resonant frequencies: 3.92, 4.89, 6.61 and 7.22 GHz with a good impedance matching. The simulated results performed by CADFEKO a Method of Moments (MoM) based Solver and measurement using Vector Network Analyzer (VNA) Anritsu MS2026C are in good agreement.

1. Introduction

For the wireless communication system, an antenna is one of the most critical components. A good design of the antenna can thus improve overall system performance. As the demand increases day by day to multi-band antennas, Thus, a major issue in multi-band communications concerns small or very small terminal dimensions, intended for short radio ranges and in association with sensors or networks for information transfer in a domestic, multimedia or professional context [1-3]. Low consumption, ease of integration, and above all cost are essential aspects that are not very compatible with performance, these antennas also have wide applications in long range of wireless systems.

Fractal Antennas Elements are currently beneficial to antenna designers & researchers. By applying fractals to antenna elements. The concept of fractal geometry was introduced for the first time by Mandelbrot in [4].

In this paper, we propose a new microstrip Sierpinski carpet antenna using a circular pattern.

2. The antenna geometry

Applying fractal theory for antenna design is a clever method of improving antenna performance thanks to the property of self-similarity that characterizes fractal geometries [5-7]. As shown in fig 1, the studied antenna is a microstrip patch antenna designed with the modification of the traditional fractal structure of Sierpinski Carpet by replacing the rectangular slots with circular ones.

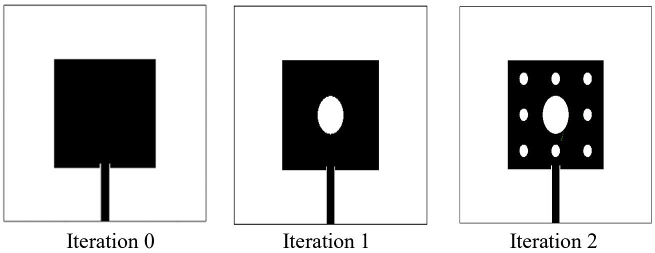

Figure 1: Iteration steps to get Carpet geometry

to excite the patch. Here, the feed is applied through a microstrip inset feed.

The table below gives the corresponding values of design parameters.

Table 1: Design Parameters & Corresponding Values

Design Parameters	Value (mm)
Length of substrate	56.02
Width of substrate	72.44
Length of patch	28.01
Width of patch	36.22
Thickness of the substrate	1.6
Width of supply line	2.8
Length of inset point	1

3. Simulation Results using FEKO suite 5.5

The following figures represent a comparison of the reflection coefficient versus frequencies for different iteration numbers.

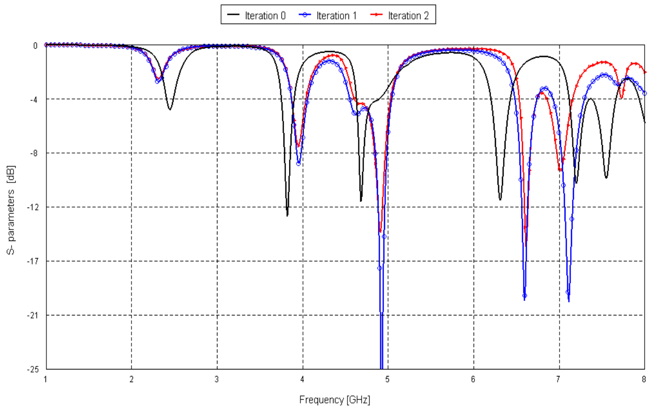

Figure 2: Simulated reflection coefficient (S11) versus frequencies for tree first iterations.

It is worth noting from the simulation that the resonance frequencies become lower when the iteration number increases. Also, for the higher frequencies, the bandwidth becomes larger.

Figure 3 shows the 3D gain pattern of the Simulated antenna for the resonance frequencies for each iteration.

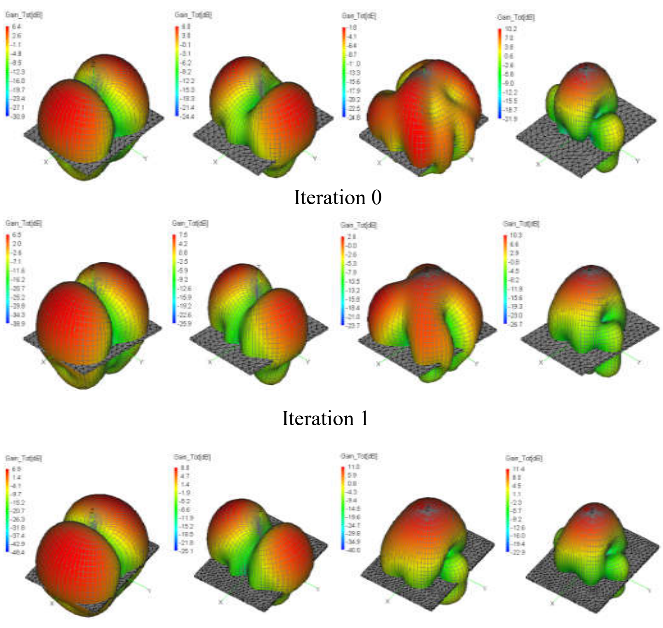

Figure 3: 3D Gain pattern of the Simulated antenna

According to the simulations, we see that the gains for all the resonance frequencies increase from one iteration to another, for example, for the first frequency F1 at iteration 0 we have the same gain 6.4dB and for the second iteration it is 6.9dB, for the third frequency the gain go from -1.8dB to 11dB at iteration 2, and for the fourth frequency F4, the gain equals 10.2dB at iteration 0 and 11.4dB at iteration 2.

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4. Experimental results

The antenna is than fabricated and tested using Vector Network Analyzer (VNA Master, Anritsu MS2026C) to validate the simulated results. We confirm with measurements that resonance frequencies become lower when the iteration number increases. Also, for the higher frequencies, the bandwidth becomes bigger.

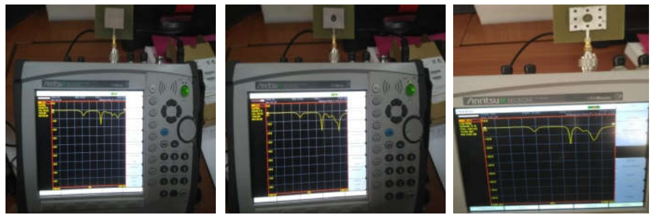

Figure 4: S_{11} Measurement by VNA for the tree antennas

5. Conclusions

In this paper, the setup of slots on the patch antenna using the Sierpinski Carpet Fractal structure allows the miniaturization of the antenna since the resonant frequency becomes smaller when increasing the number of iteration and the gain becomes higher. The simulated results performed by CADFEKO a MoM based Solver and measurement using Vector Network Analyzer (VNA) Anritsu MS2026C are in good agreement. The proposed antenna will be a good solution for many wireless telecommunications systems and especially for the embedded systems where easy integration, miniaturization, multi-band and broadband are the essential requirements.

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