Fractal Patch Antenna For GPS Application

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Abstract- Fractal patch antenna is proposed to reduce the size with miniaturization technique, not only for the single element structure, but also in an array design. This paper presents the design of fractal patch antenna based on the basic structure of square antenna operate at 1.575 GHz for Global Positioning System (GPS) application. The fractal design is introduced into the basic structure intended to reduce the frequency of operation. Hence, miniaturization can be achieved. Simulation has been performed on several sets of the design structures using Ensemble SV software. The frequency imposed by the fractal structure is lower than the basic structure.

Keywords
Fractal patch antenna, GPS, microstrip antenna.

I. INTRODUCTION

Antenna is a key building in wireless communication system since it was first demonstrate in 1886 by Heinrich Hertz and its practical application by Guglielmo Marconi in 1901[1]. Future trend in communication design is towards compact devices. Low cost of fabrication and low profile features, attract many researchers to investigate the performance of patch antenna in various ways. Fractal geometries are basically based on the shape found in nature and named such as Koch-island, Minkowski or Sierpinski-carpet. The space-filling properties of the antenna make it possible to reveal a lower resonant frequency than the basic structure [2]. The fractal can be done for several iterations until the frequency change is very small. Recent research found that the lowering of the resonant frequency would saturate after several iterations.

II. DESIGN

Basically, antenna is designed based on the wavelength, λ. It is well known that λ is given by the following equation.

$$\lambda = \frac{c}{f} \qquad (1)$$

where c is the light velocity and f is the resonant frequency. Consequently, the size of the antenna will increase as the resonant frequency decreases. The fractal antenna is designed such to obtain a smaller size antenna that can operate at the same frequency.

Square patch antenna normally designed at nearly half wavelength [1].

$$L = W = \frac{0.5\lambda}{\sqrt{\varepsilon_r}} \qquad (2)$$

where ε_r is the material dielectric constant.

Fig. 1 shows the antenna structures. The size of the basic structure is based on the Micropatch v.2 simulation result. This software allows user to design and analyze the rectangular, square and circular patch. The design had been done using GML1000.06 material with 3.05 dielectric constant and 1.524 mm thickness. The Micropatch v.2 simulation for basic square structure with coaxial feed gives the antenna size at 53.8mm x 53.8 mm in dimension and the 50 ohms point at about (19.4, 26.9) mm.

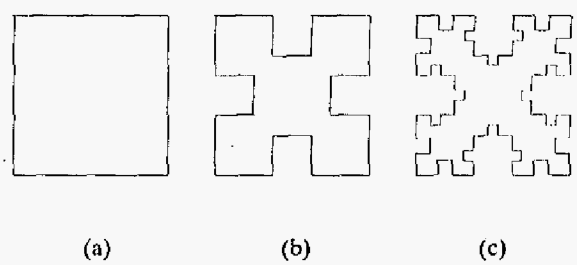

Fig. 1. The antenna structures (a) basic square, SCF, (b) first iteration fractal, FCF1, (c) second iteration fractal, FCF2

The fractal structure was designed with 0.25 iteration factor. The Koch curve removes at the center of each side is 25% of the side length due to 0.25 iteration factor. The procedure is then continued for second iteration. This process has contributed to the increases in electrical length of the antenna. Thus, the resonant frequency would decrease.

III. RESULTS AND DISCUSSION

The SCF structure had been matched with coaxial cable fed at 50 ohms point given in Micropatch v.2 simulation. Ensemble SV simulation on SCF had shown that this antenna exhibit low return loss at the corresponding GPS frequency of operation. The |S11| is approximately –20.79 at 1.575 GHz.

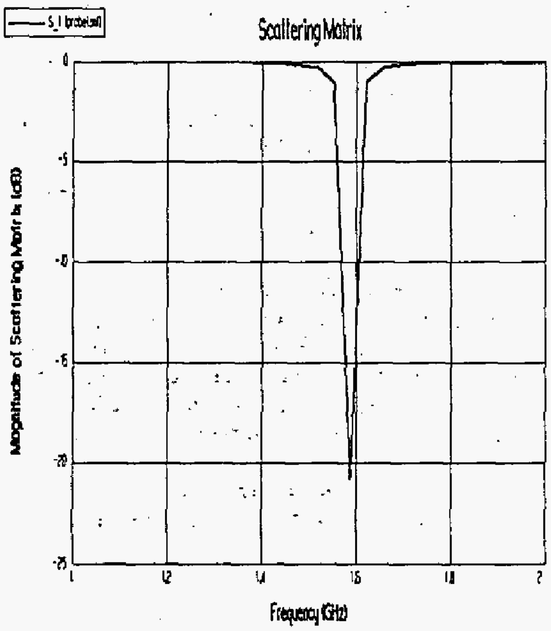

Fig. 2. Return loss of SCF vs. frequency

Miniaturization techniques on fractal structure involve the process of removing some part of the basic structure. This perturbation might change the impedance of the radiating element.

Fig. 3 shows the return loss plot for FCF1 structure fed at the same point as the basic structure. It can be seen that the frequency has drops to 1.91 GHz from 1.575 Ghz with 9.85 dB return loss. The resonant frequency drops is approximately equal to 24% from the basic structure resonant frequency. The 50 ohms point for the basic structure might not well match for the fractals. Simulations had been done for several points along y=26.9 mm axis. It was found that at point x=32, the response shows it can be operate at low return loss at about -25.96 dB.

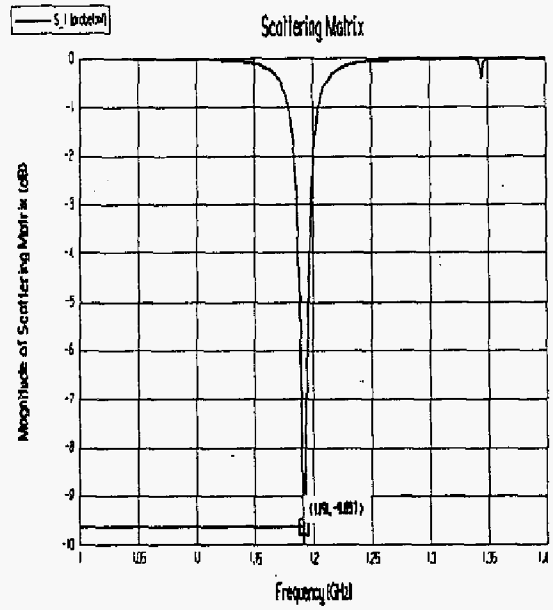

Fig. 3. Return loss for FCF1 fed at the same point as the SCF structure

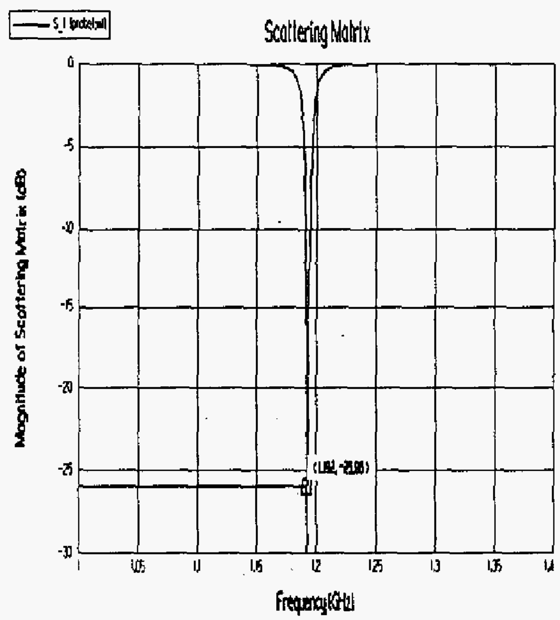

Fig. 4. Return loss of FCF1 fed at (32,26.9) mm

The second iteration structure does not show as many changes in frequency as the first iteration. FCF2 also is not well matched as it was fed at the same point with the basic structure.

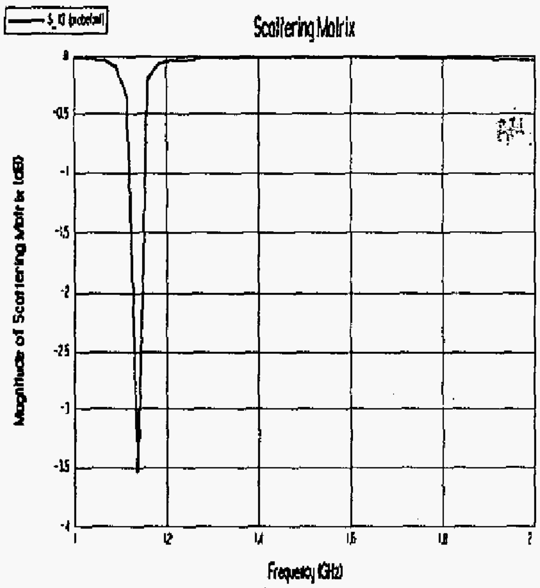

Fig. 5. Return loss for FCF2 fed at the same point as the basic structure

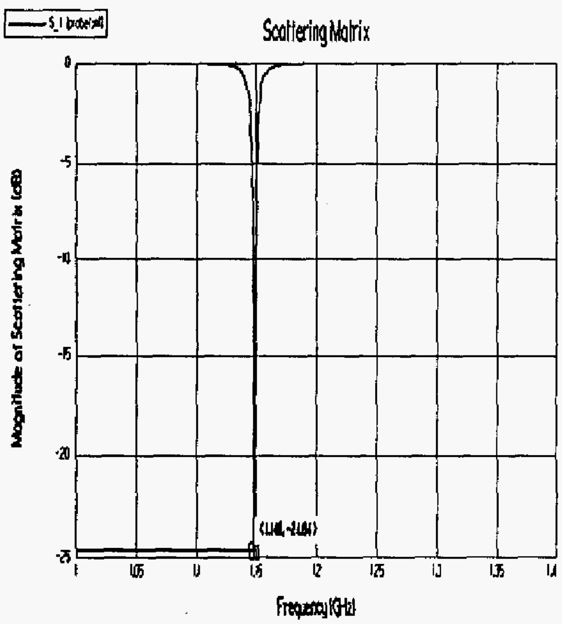

Fig. 6. Return loss for FCF2 fed at (30, 26.9) mm

The result in Fig. 6 shows that FCF2 can be operated at 1.146 GHz with –24.64 dB return loss. The frequency changes are very small compared to the changes in the first iteration structure.

Table 1. Summary of size reduction

Iteration	Resonant (GHz)	Patch size (basic square patch)	Reduction in size (%)
0	1.575	53.8 mm x 53.8 mm	0
1'st	1.192	71.4 mm x 71.4 mm	43.2
2'nd	1.146	74.3 mm x 74.3 mm	47.5

Table 1 shows the summary of size reduction for the fractal structures. Simulations show that the first iteration structure had resonated at 1.192 GHz. Conventional patch size for 1.192 GHz is about 71.4 mm x 71.4 mm. Fractal technique can reduce the size up to 43.2 %. The second iteration fractal can reduce the size about 47.5 percent. Thus the size of fractal structure antenna for GPS application can be built smaller than 53.8 mm x 53.8 mm.

IV. CONCLUSION

In this paper, the fractal structure is intended to reduce the patch antenna size. As a part of the basic structure is remove at certain iteration factor, the electrical length of the antenna increases. Thus make it possible to yield a lower resonant frequency than the basic structure. The resonant frequency had decreased as the iteration number increased. From the results, it can be conclude that this Koch Island fractal antenna can be applied in the system that require a reduction in antenna size.

V. REFERENCES

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