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Design and Fabrication of 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. Miniaturization is a must for GPS application involving highly mobile platforms and low profile antenna, like airplane, missile, etc., the frequency imposed by the fractal structure is lower than the basic structure.

I.INTRODUCTION:

Antenna is 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. Future trend in communication design is towards compact devices. Low cost of fabrication and low profile features,attract many researches 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. 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,

$$\lambda = \frac{c}{f}$$

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].

$$L = W = \frac{0.5\lambda}{\sqrt{\varepsilon_r}}$$

Where, ε_r is the material dielectric constant.

Fig.1 shows the antenna structures. The size of the basic structure is based on the IE3D simulation result. This software allows user to design and analyze the rectangular, square and circular patch. The design had been done using FR4 material with 4.4 dielectric constant and 2.4 mm thickness. The IE3D simulation for basic square structure with coaxial feed gives the antenna size at 53.8×53.8 mm in dimensions and the 50 ohms point at about (2.075,6.275)mm.

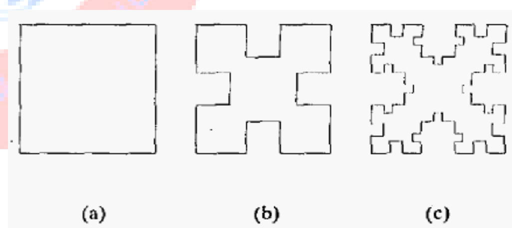

Fig: 1 The Antenna structures
a) Basic square
b) First iteration fractal
c) Second iteration fractal

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 basic square structure had been matched with coaxial cable fed at 50 ohms point given in IE3D simulation. This antenna exhibit low return loss at the corresponding GPS frequency of operation. The return loss is approximately -24.52at1.575GHz.

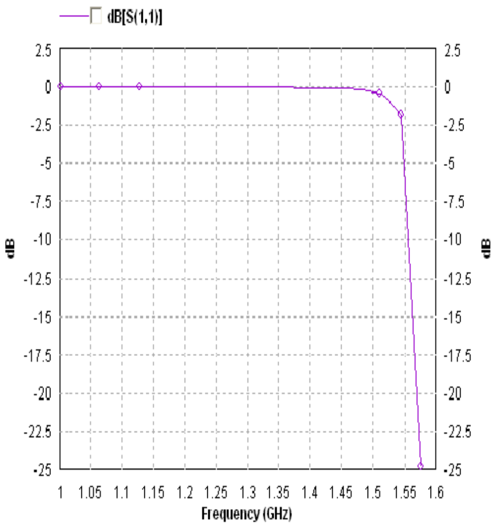

Fig. 2 Return loss of basic structure at 1.575GHz

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.

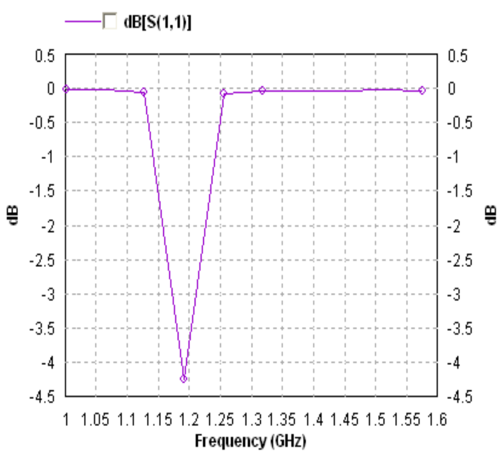

Fig.3 Return loss of first iteration at 1.191 GHz.

Fig.3 shows the return loss plot for iteration structure fed at the same point as the basic structure. It can be seen that the frequency has drops to 1.191 GHz from 1.575 GHz with 4.45 dB return loss. The resonant frequency drops is approximately equal to 38.33% from the basic structure resonant frequency. The 50 ohms point for the basic structure might not well match for the fractals.

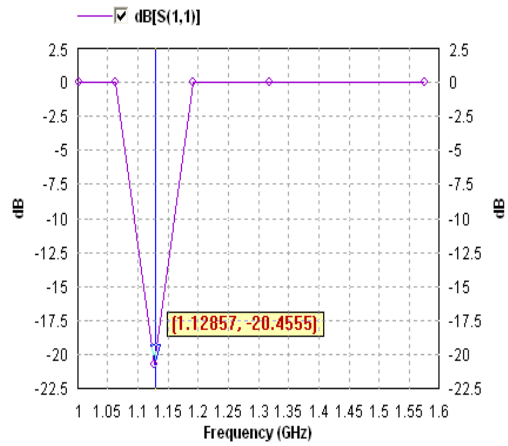

Fig. 4 Return loss of second iteration at 1.127 GHz

Fig.4 shows the return loss plot for second iteration structure fed at the same point as the basic structure. It can be seen that the frequency has drops to 1.127 GHz from 1.575 GHz with 4.45 dB return loss. The resonant frequency drops is approximately equal to 44.72% from the basic structure resonant frequency. The 50 ohms point for the basic structure might not well match for the fractals.

The result in Fig.4 shows that second iteration can be operated at 1.127GHz with -20.455dB return loss. The frequency changes are very small compared to the changes in the first iteration structure.

Table.1 summary of Frequency reduction

Iteration	Resonant GHz	Reduction in frequency (%)
0'th	1.575	0
1'st	1.19167	38.33
2'nd	1.12778	44.72

Table.1 shows the summary of frequency reduction for the fractal structures. Simulations show that the first iteration structure has resonated at 1.191 GHz. Conventional patch size for 1.191GHz is about 57.8×57.8mm.Fractal technique can reduce the frequency up to 38.3%. The second iteration fractal can reduce the frequency up to 44.72%. Thus the size of fractal structure antenna for GPS application can be built smaller than 53.8×53.8.

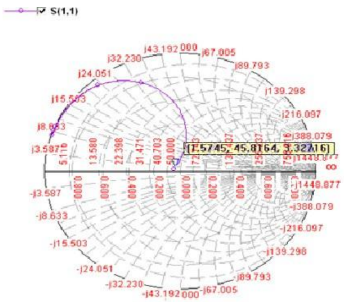

Fig.5 Impedance of basic square patch at 1.575GHz

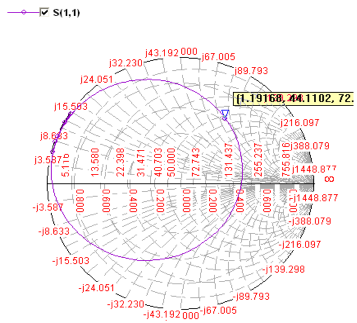

Fig.6 Impedance of first iteration at 1.191 GHz

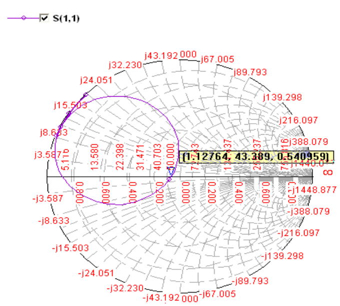

Fig.7 impedance of second iteration at 1.127 GHz

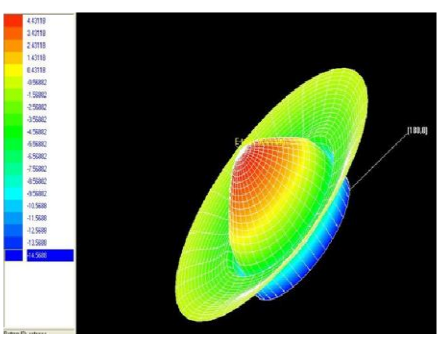

Fig.8 Gain of basic square patch at 1.575GHz

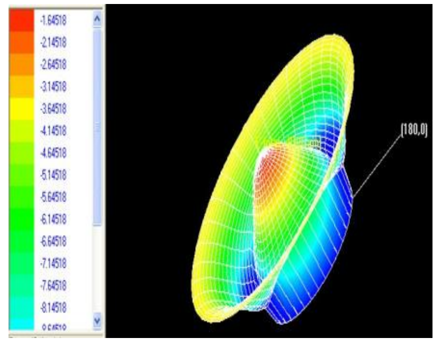

Fig.9 gain of first iteration at 1.191GHz

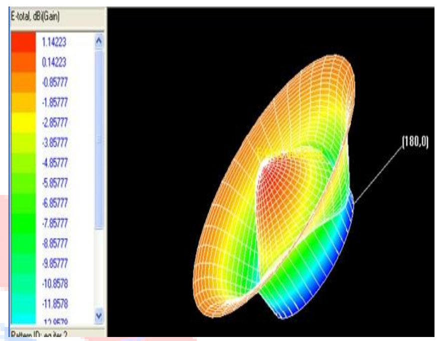

Fig.10 Gain of second iteration at 1.127GHz

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 in 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 concluding that this Koch island fractal antenna can be applied in the system that requires a reduction in antenna size.

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