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Design and Development of Switchable Fractal Patch Antenna for GPS Application

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Abstract - *This paper presents stacked fractal patch antenna for reducing radio frequency interference. Mitigation of intentional and unintentional jamming of GPS signals is a must in the antenna design for robust system performance. To achieve this, two fractal patch antennas with different radiation patterns are stacked one over the other and they are selected using diode switching. This combination of features is packed in a single antenna unit that can be a direct replacement of existing antennas. Fractal patch antenna is proposed to reduce the size with miniaturization techniques, not only for the single element structure, but also in the stacked design. The designs of fractal patch antenna operate at 1.776 GHz for Global Positioning System (GPS) application. The fractal structure is introduced into the basic structure intended to reduce the frequency of operation. Hence miniaturization can be achieved. Simulation has been performed using software package Zeland IE3D.*

Keywords: *Patch Antenna, GPS, Fractal Patch Antenna.*

INTRODUCTION

Antenna is a key building in wireless communication and Global Positioning system since it was first demonstrate in 1886 by Heinrich Hertz and its practical application by Guglielmo Marconi in 1901[l]. 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 parch 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. Fractals can be used to miniaturize patch elements as well as wire elements, due to their space filling properties. The space concept of increasing the electrical length of a radiator can be applied to a patch element.

I. ANTENNA CONFIGURATION

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

$$\lambda = c/fo \qquad (1)$$

where c is the light velocity and fo 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. The width and length of the patch antenna are calculated as follows:

$$W = \frac{c}{2 f_0 \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

$$L = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

Where εr is the dielectric constant εreff is the effective dielectric constant.

1.1 Fractal Patch Antenna

Fig 1 shows the antenna structure 1.The basic patch antenna is 50.71mm long and 39.15mm wide with a height of 2.4mm.The antenna structure is exteremely simple, yet offer good RF performance giving a single resonant frequency. The microstrip patch antenna is fed with a coaxial feed at about (-10,17)mm.

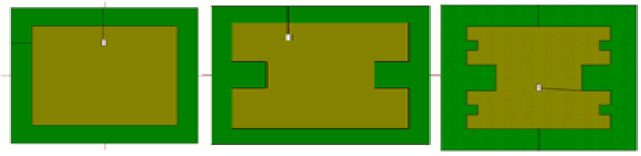

Fig. 1: The Antenna Structures 1(a) Basic Square (b) First Iteration Fractal (c) Second Iteration Fractal.

TABLE 1: SPECIFICATIONS OF ANTENNA STRUCTURE1

Parameters	**Dimensions**
Rectangle Length	50.71mm
Rectangle Width	39.15mm
Patch Thickness	2.4mm

The fractal structure was designed with 0.25 iteration factor. The Koch curve removes at the centre 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.

1.2 Stacked Fractal Patch Antenna

The antenna has two Fractal patch antenna elements with different radiation pattern. The two antenna elements are in sufficiently close proximity to each other that strong mutual coupling would normally takes place, disrupting their independent operation. The two antenna elements may be operated independently of each other by selectively disabling one or the other of the two elements. More specifically, diodes are used to isolate the two elements so that, in operation, the elements can be used independently, giving two radiation patterns. In one selected mode, a nominal radiation pattern provides a broad, hemispherical shaped sensitivity that is designed for acquiring and tracking all navigation satellite above the horizon. The second selectable radiation pattern of the dual element has higher gain towards horizon and lower gain at and below the horizon to mitigate interferences. In the two fractal patch antenna, the upper dielectric substrate has a high dielectric constant so that the size of the upper patch minimized. The dielectric constant of 4.4 yields an upper patch element. The lower dielectric substrate preferably has a very low dielectric constant near or equal to 1.0.This results in the large lower element whose edges have a length of approximately one-half wavelength at the design frequency.

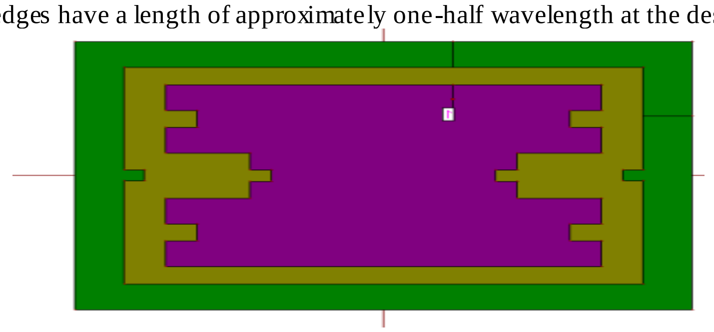

Fig 2: Stacked Fractal Patch Antenna 2

TABLE 2: SPECIFICATIONS OF ANTENNA STRUCTURE2

Parameters	**Lower Patch Dimensions**	**Upper Patch Dimensions**
Rectangle Length	50.71mm	102.87mm
Rectangle Width	39.15mm	107.14mm
Patch Thickness	2.4mm	3mm
Dielectric Constant	4.4	1

II. SIMULATION RESULTS

These antennas are meshed with meshing frequency 1.8, 1.227, 1.176GHz. Scattering matrix parameter, voltage standing wave ratio parameter, impedance matching are noted here. Fig. 3, 4,5 Shows the antennas return loss is less than -10 db in S(1,1)parameter display.

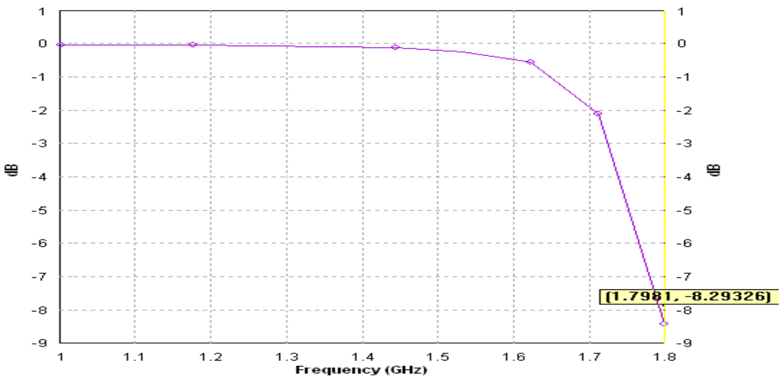

Fig. 3: S-Parameter Display of Basic Patch Antenna at 1.8GHz

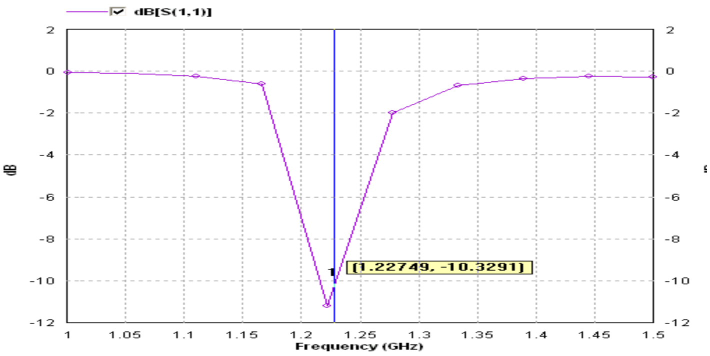

Fig. 4: S-Parameter Display of First Iteration Fractal Patch at 1.227GHz

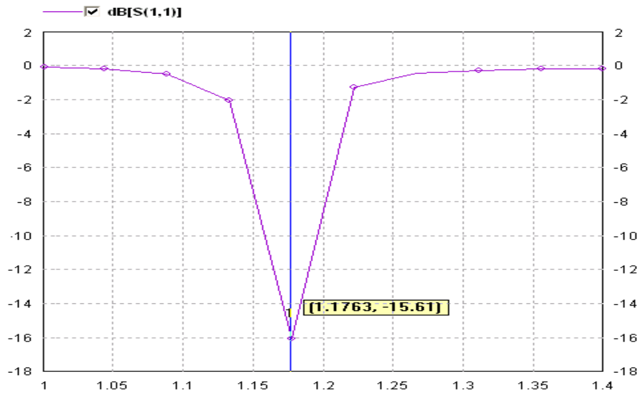

Fig. 5: S-Parameter Display of second Iteration Fractal Patch at 1.776GHz

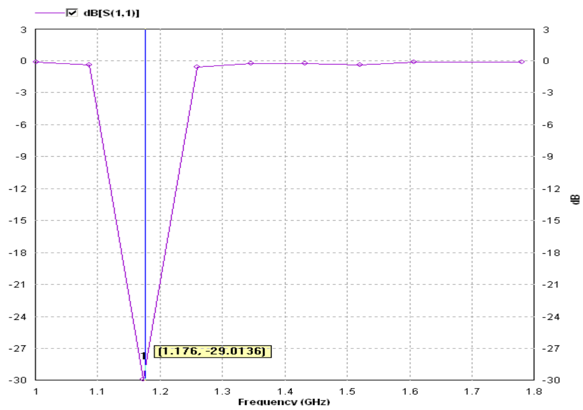

Fig. 6: S-Parameter Display of Stacked Fractal Patch Antenna 2

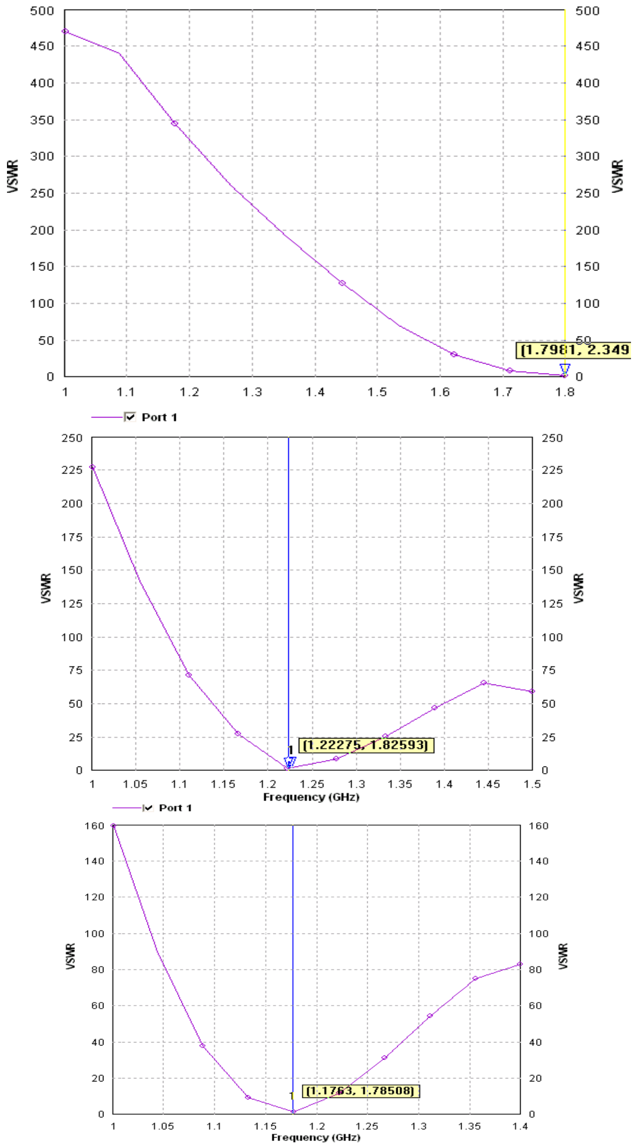

Fig. 7: VSWR of Antenna Structures1 at Frequencies
1.8, 1.227, 1.776GHz

The VSWR indicates the mismatch between the antenna and the transmission line. It is got for the resonant frequencies the VSWR value closer to unity. Simulated maximum antenna gain is close to 2 db.

Fig. 8: VSWR of Stacked Fractal Patch Antenna

Impedance parameters display is shown in fig.9 and 10 for antenna 1 and antenna 2 respectively. Around 50 ohms impedance is got for the resonant frequencies in both real and imaginary curves. Smith chart results of these antennas show good radiation characteristics and is shown in fig. 9 and fig. 10.

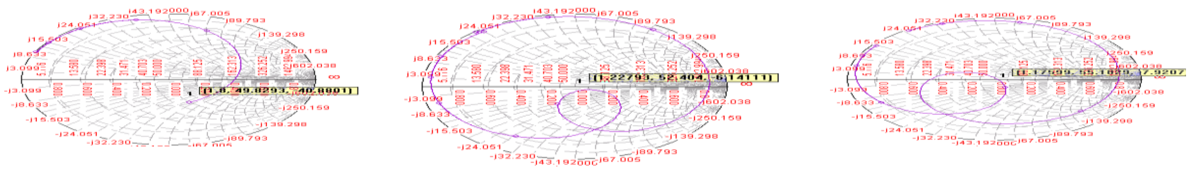

Fig. 9: Smith Chart of Antenna Structure1

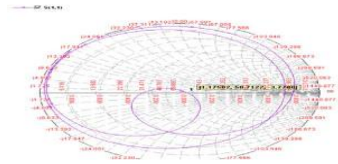

Fig. 10: Smith Chart of Stacked Fractal Patch Antenna 2

TABLE 3: COMPARISON OF ANTENNA PERFORMANCES

Parameters	**Antenna Before Stacked**	**Antenna After Stacked**
Return Loss(db)	-15	-29.01
VSWR	1.78	1.30
Smith Chart	55.1	56

TABLE 4: SUMMARY OF SIZE REDUCTION

Iteration	**Reduction(GHz)**	**Reduction in size(%)**
0	1.8	0
1st	1.227	57.3
2nd	1.176	62.4

Table 4 shows the summary of size reduction for the fractal structures. Simulations show that the first iteration structure had resonated at 1.227 GHz. Conventional patch size for 1.227GHz is about 74.39mm×57.83mm.Fractal technique can reduce the size about 62.4 percent.

III. 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. The stacked fractal patch antenna with a capacity of rejecting jamming.

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