Toward an optimum design of fractal sausage Minkowski antenna for GPS applications

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ABSTRACT

Fractal is one of the important tools to produce efficient and well-suited antennas for navigation systems. A novel design of broadband fractal sausage Minkowski antenna is described in this research article. Sausage Minkowski is designed and simulated for global positioning system (GPS) application that relies on fractal geometry using computer simulation studio microwave (CST MW) software. The substrate sheet is Roger TMM4 has of 4.5 dielectric constant and 1.6 mm altitude. A small metallic patch over a large metallic ground layer is made of perfect electric conductor (PEC) material. The suggested fractal antenna can be used efficiently in the military applications which demand a narrow spectrum and a tiny antenna profile. By introducing four various levels of fractal iteration models and compared each one to the other. The main aim of this work is to increase antenna gain and reduce the antenna size, in addition to improving the semi-flat voltage standing wave ratio (VSWR) with respect to decreasing the resonance frequency is. For 10% decrease in the frequency for the 3rd iteration value led to a clear improvement in the antenna characteristics such as directivity, gain, and VSWR. The reflection coefficient and bandwidth remain in range.

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1. INTRODUCTION

Recently, body-worn antenna was attracted in modern telecommunication system consequently to their attractive features like low profile; light weight and compatibility to radio frequency integrate circuits. These radiating elements should be small and light enough to work properly approximately the human being body [1], [2]. In spite of investigating the enlarged gain and minimized antenna profile is crucial. The technology growth like Internet, mobile telecommunications has led to personal users desiring wireless access for security, networks, cell phones, low power system and wireless broadband such as TDMA, stands for time division multiple access, FDM, symbolises the frequency division multiplexing, and CDMA, for code division multiple access. In parallel at the same time most engineers aim to decrease the profile and enhance the instruments efficiencies. Generally, the gain of radiating element can be introduced by the ratio of the power radiatied to a specific direction and the isotropic direction power [3]. One of the techniques used for directivity and gain improvement is a method of layer reflection [4].

A cheap microstrip antenna operating at bandwidth from 12.8 GHz to 15.83 GHz is designed. The producing of the bandwidth based on the methods of both DGS, stands for dishonorable ground structure and engraving antenna slots [5]. Design a coplanar waveguide (CPW) fed octagonal antenna specified for bandwidth from 2.45 to 5.80 GHz with an inverted E slot coupling in the patch antenna [6]. The work of enhanced Quadri-band microstrip patch antenna based on dishonorable slots for the metallic ground is adopted to operate in mm wave band [7]. The investigation and development of multi notch band filters utilizing tree fractal geometry is presented in [8]. Presenting and simulation of an original CPW radiation element to be candidate for ultra-wideband (UWB) has been done in [9]. The influence of radiation is studied for 4 levels of fractal iteration [10].

The proposed sausage Minkowski square patch antenna might be appended to life coat to target finding the human body on the off chance that a mishap occurred, so that a particular SAR, stands for specific absorption rate has to be determined and limited to be conceivable. Fractals are geometric shapes that recurrent itself over an assortment of scale measures so the shape looks the equivalent saw at various scales. Along these lines, our plan based on fractal structure for four models of iteration to enhance gain and directivity for operating the proposed antennas appropriately in L band. The low SAR antenna structure works in the frequency of 2.4 GHz [11]. An antenna, that is multiband based, uses new fractal analysis was introduced by forming and engraving a circle that contains hexagonal slots [12]. Some shapes, specifically fractal trigonometric based, are examined while numerous structures are utilized for the sake of creating ultra wideband based transmitting-receiving antenna [13]-[15].

A novel fractal sausage Minkowski was designed and simulated for decreasing SAR [16]. There are several types of Sierpinski like gasket [17] and carpet [18]. Comprehensive study and analysis with details for various approaches and methods implementing in radio frequency identification (RFID) antenna are presented in [19]. Figueroa and Medina presented an experimental design for a wideband antenna at (8-12) GHz band based on Sierpinski structure. Various methods are employed to improve the characteristics of antenna like fractal structure [20], defected ground configuration [21] and patch cutting slots [22], [23]. This research article deals with the design and simulation of four various levels of fractal iteration and compared each one to other. By increasing the gain, directivity, fixing semi flat VSWR, and decreasing the antenna size, that led to a suitable radiating element for some special military and security application.

2. METHODOLOGY AND MATERIALS

2.1. Fractal sausage Minkowski configuration

Two criteria to make the radiating element function admirably at all frequencies: first is the dimensions of the certain antenna has to be symmetric to a specific tagged point, second, such antenna has to be divided into several parts, each owns a decreased in size, and duplicate the entire that draws it as fractal. The simulation of our work has been achieved by operating CST-MW software. Four essential stages have produced the design, the former stage has included an initial design. However, the length is expanded to plan the self-comparative fractal. The fractal structure has been utilized for scaling down the components that belong to the radiator element, which has been utilized in present, which work in huge resounding frequencies [24]. Rule of activity of fractal rely upon iterative numerical procedure, that is depicted using iterative capacity framework (IFS) calculation. The fractal sausage Minkowski has been determined as appeared in Figure 1. The came about fractal by supplanting every side that belongs to the square with the messed up line has been appeared, and applying this strategy on the subsequent polygons, repeatidely [25]. The dimension of each section is determined as in condition (1):

$$li=(1/\sqrt{5})^n \quad (1)$$

Where li denotes the fragment length, n denotes the iteration degree.

Figure 2 delineates the means that belongs to the configuration of thefractal in regards to the Sausage Minkowski fix reception apparatus. Subsequently, it was calculated by combining the first 3 of such polygons [26]. For which, the S(n), symbolises the side-number, is equivalent to 4(3n). It is worthe mentioning that the fourth polygon has recorded S(4), which is equivalent to 324 sides.

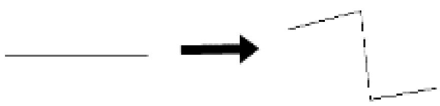


Figure 1. Fractal sausage Minkowski geometry

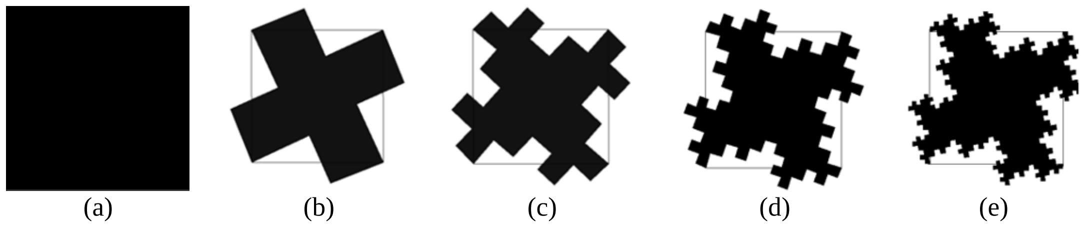


Figure 2. Fractal sausage Minkowski, (a) zero iter, (b) first iter, (c) second iter, (d) fourth iter, and (e) fifth iter

2.2. Investigation of the proposed fractal antenna

Four models of iteration from 1st iteration to 4^{th} iteration are shown in Figures 3 (a)-(d). To implement first iteration for the suggested square patch antenna, that is fractal sausage Minkowski, n will equals to 1, so the length of each side will be calculated from the relationship $(\frac{1}{\sqrt{5}})LP$i where LPi is the side dimension. By increasing the index n, the other fractal can be determined by using the same relationship.

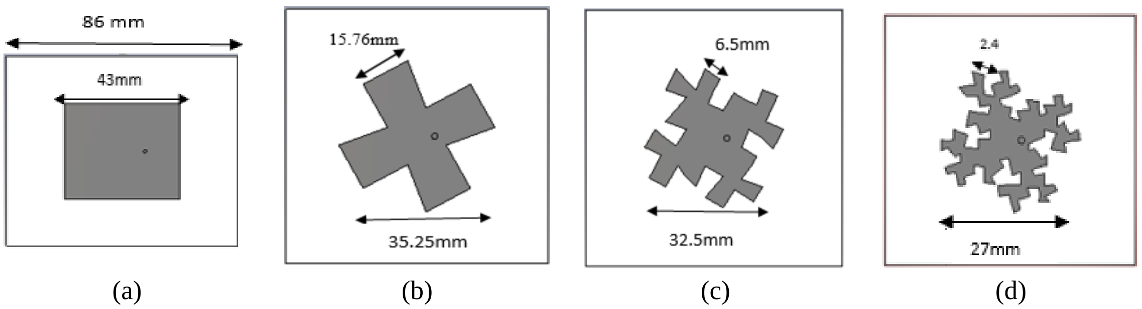


Figure 3. Models of iteration, (a) 0 iter, (b) first iter, (c) second iter, and (d) third iter

3. RESULTS AND DISCUSSION

To verify the proposed antenna, several iterations are simulated to understand the trends that govern the antenna to be the better. CST MW software is used in simulation. Microstrip antennas were designed using Roger TMM4 substrates. The ε_r is equivalent to 4.5 for the substrate, the lattes owns a thickness that is equivalent to 1.6 mm. The simulated results were obtained using CST studio MW. Patch is made from PEC material with 0.6 mm thickness. Antenna characteristics such as gain, radiation pattern, return loss and standing wave ratio were tested and the results are reported. The Figures 4-6 show the return losses for three iteration and the values of the resonant frequency are recorded with a shifted back as the iteration increases.

While, in Figures 7, the radiation pattern is shown as directivity. And note that the values of directivity are increased with the increase of number of iteration. The third iteration is recorded max. value with 6.57 dBi. All the characteristic parameters belong to the antenna have been listed as mentioned in Table 1. From this table, the 3^{rd} iteration of sausage Minkowski fractal is recorded best values.

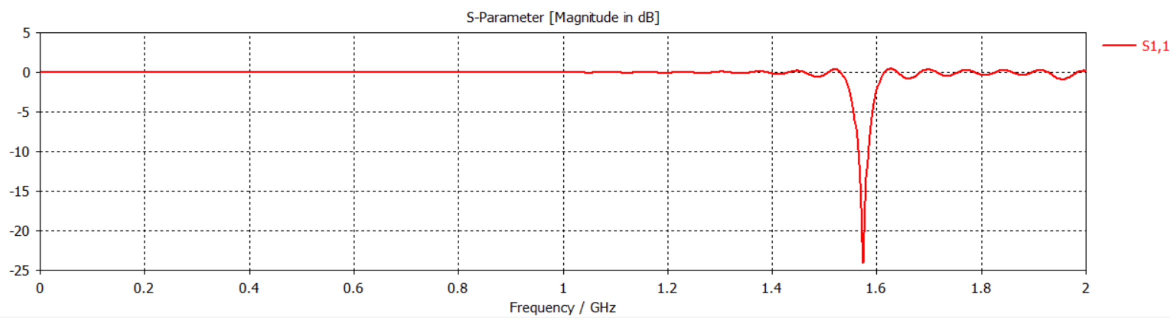


Figure 4. Reflection coefficient 1^{st} iteration

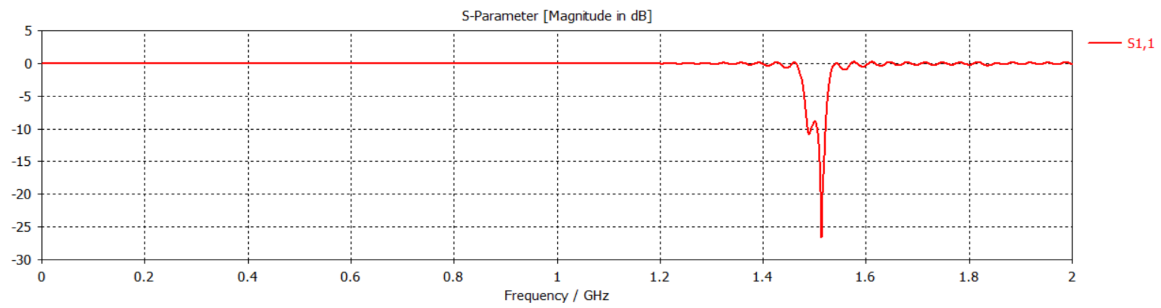


Figure 5. Reflection coefficient 2nd iteration

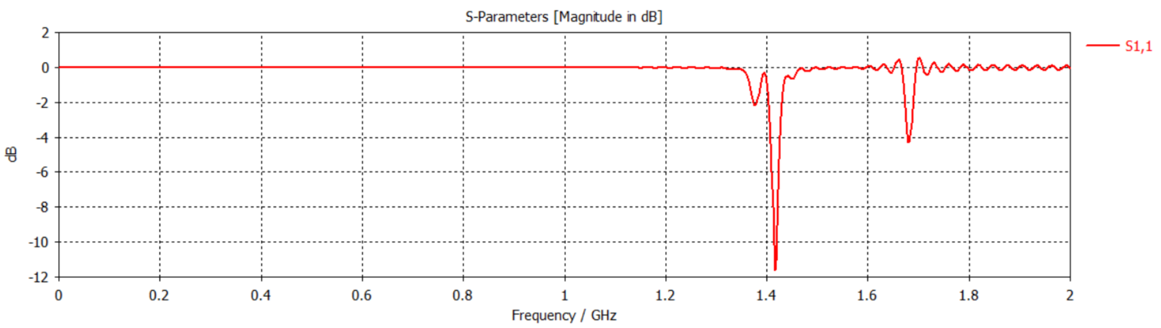
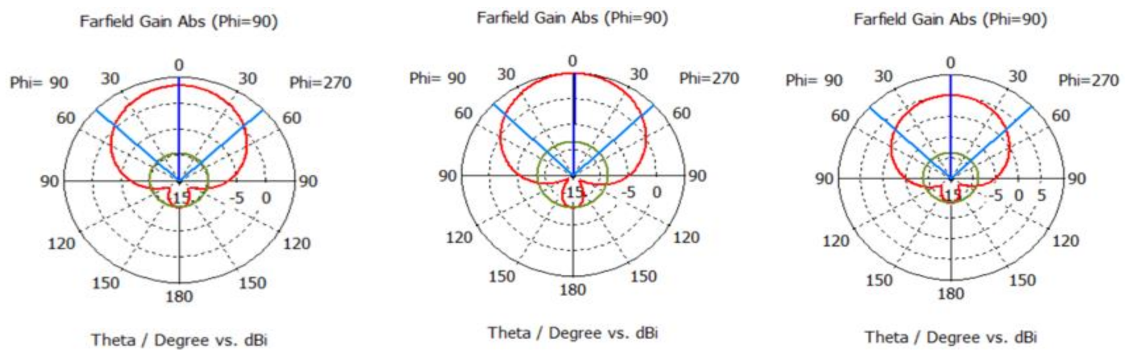


Figure 6. Reflection coefficient 3rd iteration



(a) (b) (c)

Figure 7. Radiation pattern as directivity for sausage Minkowski antenna, (a) 1st iteration, (b) 2nd iteration and, (c) 3rd iteration

Table 1. The characteristics of antenna for sausage Minkowski antenna

Characteristics of antenna	1st iteration	2nd iteration	3rd iteration
Freq.	1.575	1.514	1.415
RL	-24.5	-26	-12
SWR	1.17	1.12	1.1
Gain	3.36	4.9	5.03
Directivity	6.49	6.52	6.57

4. CONCLUSION

Microstrip patch antenna, type sausage Minkowski has been introduced with low profile and on top of that, is a unidirectional. Four levels of fractal iteration have been utilised to decrease the antenna size and improving the antenna gain to a level that can reach 5.03 dB. On the other side, the directivity of the intenna has been enhanced and improved to a level that is equal to 6.57 dBi, concurrent with a standing wave ratio, that is equivalent to 1.1. Moreover, the proposed antenna has showed the required flexibility at the time of optimization. Besides, the results maintained an acceptable value of return loss. The sausage Minkowski antenna is low complexity, considerable gain and directivity and small size make it candidate for special application such that military and security applications.

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