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Efficient Wearable Electro-Textile Antennausing Minkowski Fractal Geometry With Tuning Holes

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Abstract: This paper manages scaling down and tuning of wearable electro-textile antennas by the utilization of Minkowski fractal geometries and tuning holes. Different electro-textile materials used for wearable electronics (like polyester fabric.) are considered for the substrate (or dielectric medium) configuration of microstrip antennas. In the essential outline these antennas are intended for WLAN applications and hence specifically tuned by tuning holes designed over the patch. The path antenna with tuning holes gives an increase of 3.2 dB with an impedance bandwidth of 150 MHz though, the change in material offers an addition of 3.4 dB and an impedance bandwidth of 162 MHz. By applying holes in Minkowski fractal geometry to the antennas, tuning is accomplished. Also the impact of different iterations are also considered to make them suitable for GSM 1900 applications. In these analysis, the performance and limitations of these designs in accordance with their separate operating environment are also compared. The reenactment studies uncover that tuning holes yields better results contrasted with normal antenna.

Keywords: Fractal Antenna, Antenna Tuning.

1. INTRODUCTION

Improvement of wearable microstrip antennas has quickly expanded in the recent past, asmicrostripdesignis simpleton shape. Antenna properties suchas minimized size, simple creation; mechanical adaptability and ease are crucial necessitiesto plan antennas for wearable applications. The idea of creating reduced antennas by applying scaling down procedure utilizing fractal geometry was already proven technique.The fractal parts produce "fractal loading" and permit the formation of smaller sized antennas for a given frequency of operation. Normally 50-75 percent shrinkage is achievable by utilizing a fractal configuration while maintaining the performance. Fractal antennas likewise give numerous other advantages likethey can be amazingly little for applications obliging an installed antenna, for transparent substrate materials it is possible to designnearly imperceptible bigger scale structure, it also has lowers cost and enhances desirability. The objective of this paper is to study, analyze, design and describe wearable fractal antennas capableof working with Modern wireless standards. Various structures of fractals are tested in order to achieve a comparison between them and the parameters like radiation patterns, return loss, BW, SWRcurves, input impedance are used to compare these antennas.Other objective is to make an antenna capable to operate according to the IEEE 802.11 standards (802.11a = 5,235 to 5,350 GHz and 5,725 to 5,875 GHz,802.11b = 2,412 to 2,472 GHzand 802.11g = 2,412 to 2,472 GHz). The rest of the paper is organized as follows: second section describes theproperties of Minkowski island fractal and its generation process. The third sectionpresents the antenna design parameters. Then the performance characteristicsof all designed antennas are compared infourth section. Finally the conclusion is drawn on the basis of these results are show infifth Section.

2. MINKOWSKI FRACTAL GEOMETRY

A fractal can be depicted as a rough or divided geometric shape that can be differentiated into parts which are a close estimation to the entire geometry yet in a decreased size. Fractals are considered as infinitely complex due to its comparability at every resolution. The fractal geometries have been known for very nearly a century, although its application in fractal antennas is moderately new approach.Studies here demonstrate that fractals have great electromagnetic radiation examples and preferences over conventional antennas which makes them suitable for modern communication system.
The first known fractal antenna in built by Nathan Cohen in 1988. This Nathan Cohen concept consists that bending the wire in such fractal way maintains the overalllength of the antenna but reduces the size in successive iterations, which can be utilized for implementation an efficient miniaturized antennas. Furthermore the fractal antenna exhibits thesame or higher gain, frequencies of resonance and a 50Ω termination impedance even with being smaller size than the Euclidean one. Also since the Fractal antennas uses a fractal, (i.e. the self-similar repetitive design)hence it can achieve multiple frequencies because of self-similar structure repetition atdifferent scale, which facilitiesit greater bandwidth and can achieve non- harmonic resonant frequencies at differentband. Minkowski island fractal is presented in figure 1(a). The fractal is formed by removing the centered one-thirdsegmentfrom each side byindentationwidth which is defined as the product of indentation factor to the indentation length. The above operation results the formation of five segments for every one of the previous iteration, at different scales. The indentation factor can be used to a shift in the resonant frequencies.

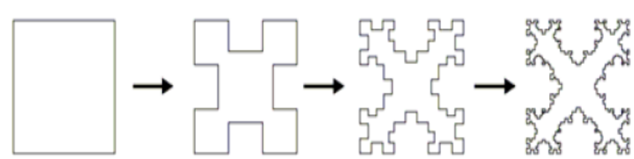

Figure 1: *Formation of Minkowski island fractal at different iterations.*

3. PROPOSED ANTENNA STRUCTURE

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To design started with, rectangular shape of size 38mm X 48.4mm X 0.1524 mm (Flectron) with Indentation factor of 0.5 and iterated for the 2 times over the substrate of dimension 120 mm X 120 mm X 2.85 mm and with same size of ground plane however the material and thickness of the ground plane are same as of patch. Now the formed antenna structure is fed by an aperture using microstrip line. The microstrip feeder line dimensions are taken for 50ohm characteristic impedance.

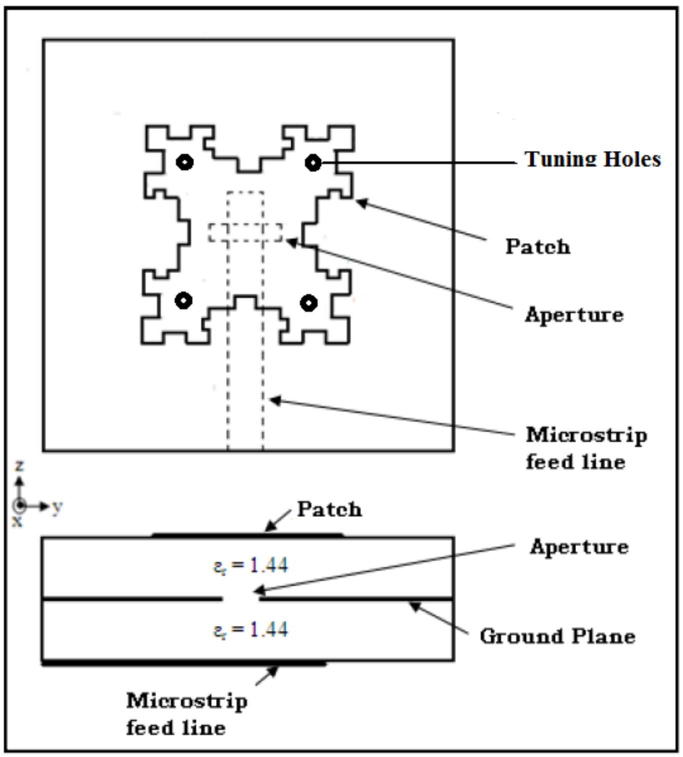

Figure 2: *Structure of the proposed antenna with tuning holes*

4. PERFORMANCE CHARACTERISTICS

The performance of the presented antenna is calculated for the frequency range of 1.0 GHz to 4.0 GHz.The simulation results shows that the presented wearable antenna resonates at a frequency of 2.44 GHz, 2.29 GHz and 1.93 GHz for 0^{th}, 1^{st} and 2^{nd} iterations respectively with the return loss of -10dB and return loss bandwidths are 130 MHz, 100 MHz and 63 MHz respectively. This concludes that resonant frequency of antenna got reduced considerably with each iteration while maintaining the overall antenna size.

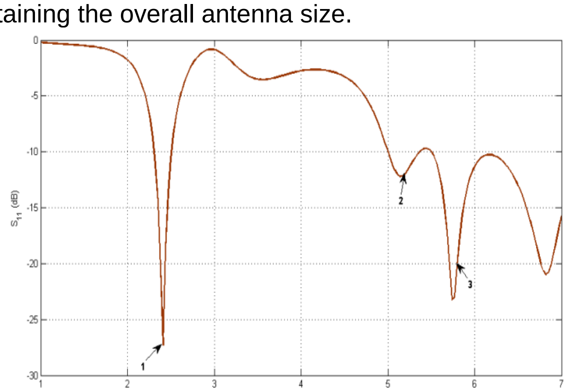

Figure 3: *Return Loss characteristics of proposed antenna for 0^{th} iteration.*

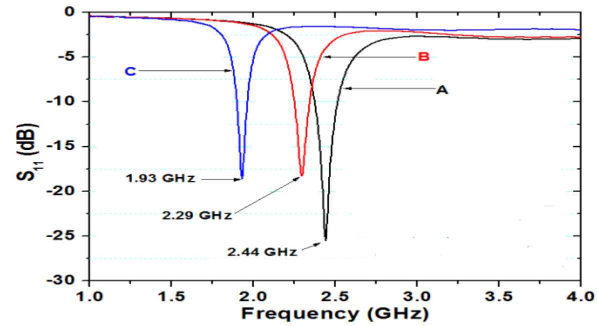

Figure 3: *Return Loss characteristics of proposed antenna for all iterations.*

Simulations are also performed for antenna parameters like gain, directivity, beam-width which are shown in figure 4, 5 and 6 respectively. Which shows the antenna gain of 5.9 dB 5.0 dB and 1.65 dB at 0^{th}, 1^{st} and 2^{nd} iterations respectively with the radiation efficiencies and directivity of 60.1 %, 8.1 dBi, 48.9 %, 8.4 dBi and 35.6 %,8.1 dBi respectively.

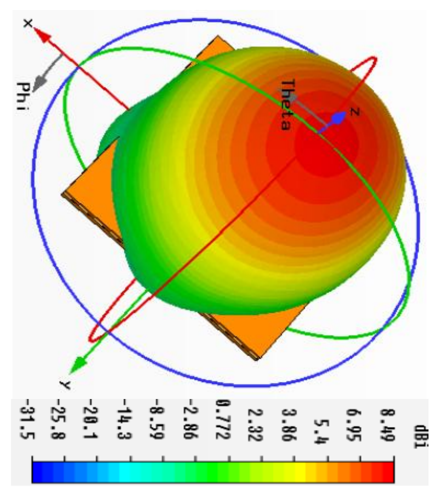

Figure 4: *Radiation Pattern of ProposedAntenna for 0^{th} iteration.*

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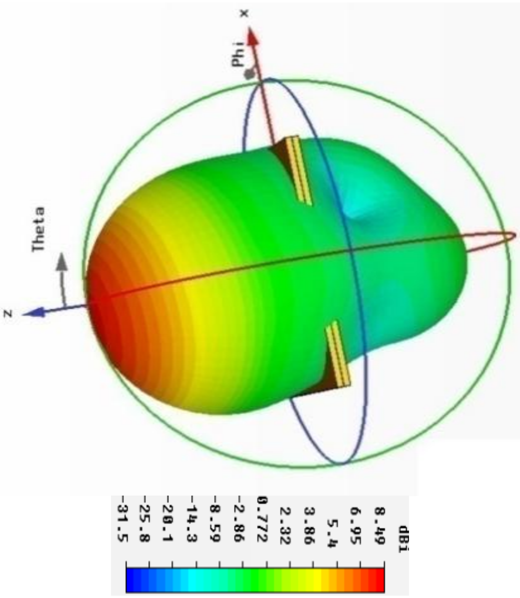

Figure 5: *Radiation Pattern of ProposedAntenna for 1ts iteration.*

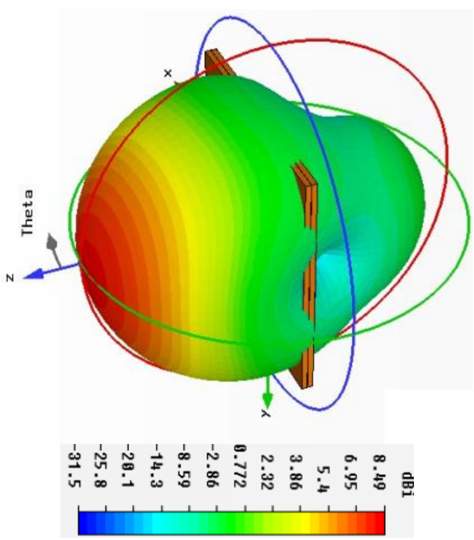

Figure 6: *Radiation Pattern of Proposed Antenna for 2nd iteration.*

5. CONCLUSION

In this paper, a wearable electro-textile antennas is designed by using Minkowski fractalgeometries with tuning hole for0th, 1st and 2nd iterations.In the 0thiteration, the antenna dimensions are optimized for WLAN frequency band. In the 1st and 2nd iterations the fractal geometry parameters are fine tuned for WIBRO and GSM 1900 bands. The results shows that the designed antenna provides gives good performance characteristics in all the three frequency bands and the tuning hole could be used to fine tune the antenna without increasing the complexity and compromising the rigidness of structure.

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