Electro-Textile based wearable Antenna with Tuning

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ABSTRACT

This paper deals with miniaturization of wearable electro-textile antennas by use of Minkowski fractal geometries. Tuning holes give desired result when change the position of holes. In this case, polyester fabric material has been employed as dielectric medium. CST simulation results provides a gain of 6.897dB & Directivity 8.15dBi with an impedance bandwidth of 82 MHz by applying Minkowski fractal geometry to the antennas, miniaturization is achieved. Impedance and radiation characteristics of 2.45 GHz wearable antennas in close proximity to human body are discussed in this paper. There are two major features causing the capacity increase for the proposed system: 1) the high efficiency of the electro-textile antennas that can be seamlessly embedded into human clothing; 2) significant system diversity gain due to the wide spacing among antennas in the distributed body-worn system. Antenna are designs for WLAN application Antenna structure is designed at a height 2.85mm from the ground plane by using Computer Simulation Technology (CST) software. The operating frequency of the design antenna is 2.45 GHz. Antenna simulation results are carried out over the frequency range of 1.0 GHz to 6GHz for Flectron antenna under investigation. The simulation result reveal that the Flectron wearable antenna operating frequency of 2.538GHz,2.395GHz, 2.351GHz and 2.340Ghz for zeroth,1st ,2nd and proposed iteration respectively. Corresponding -10dB return loss bandwidths are 115MHz, 109MHz, 104MHz and 82 MHz respectively.

Keywords: Fractal Antenna, Antenna Tuning.

I. INTRODUCTION

In Modern area of technology lots of research is going on in the Wireless Technology. Fractal geometry is a recursively produce structure having self-similar shape which means that some of the parts have the same shape as the whole object but at different scale. In the essential outline these antennas are proposed for WLAN applications and hence specifically tuned by tuning holes designed over the patch. With the help of tune in holes we Provides multilevel frequency for is different application. The patch antenna with tuning holes gives a supplement of impedance bandwidth though the change in material offers and addition of an impedance bandwidth by is appropriate holes. In other words these antenna features can now be quantitatively linked to the fractal dimension of the geometry. Dissimilar

Iterations are also considered to make them suitable for GSM 1900 applications. In this an analysis the performance and limitations of these designs in accordance with their separate operating environment are also compared. This finding can lead to increased flexibility in designing antennas using these geometries. The relationship between the fractal dimension and multiband characteristics of fractal shaped antennas has been verified using other fractal geometry tries as well Antenna properties such as minimized Size, simple creation; mechanical adaptability and Ease is crucial necessities to 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.

2. MINKOWSKI ISLAND 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 innately 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 a moderately new approach. Studies here demonstrate that fractals have great electromagnetic radiation examples and preferences over conventional antennas which make 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 overall length of the antenna but reduces the size in successive iterations, which can be utilized for implementation an efficient miniaturized antennas. The fractal geometry defines a structure with long lengths that fit in a compact area. This feature of fractals can be used to design miniaturized resonant antennas due to their reduced physical lengths. The shape of the fractal is formed by an iterative mathematical process. This process can be illustrated by an iterative function system (IFS) algorithm, which is based upon a series of affine transformations [Werner and Ganguly (2003)]. An affine transformation in the plane ω can be written as:

$$w\begin{pmatrix}x_1\\x_2\end{pmatrix} = Ax + t = \begin{pmatrix}r_1 cos\theta_1 & -r_2 sin\theta_2\\ r_1 sin\theta_1 & r_2 cos\theta_2\end{pmatrix}\begin{pmatrix}x_1\\x_2\end{pmatrix} + \begin{pmatrix}t_1\\t_2\end{pmatrix}$$

Where x_1 and x_2 are the synchronize of point x. If r1=r2=r with 0<r<1, and θ1=θ2=θ, the IFS transformation is a contractive similarity (angles are preserved) where r is scale factor and θ is rotation angle [4]. The column matrix t is just a translation on the plane.

Applying several of this conversion in a recursive way, the Minkowski island fractals are obtained as depicted in Fig.1. in the beginning the initiator is a square which can be regarded as a zeroth order of the Minkowski island fractal (F1).The first iteration of Minkowski island fractal by removing the middle third of each side by some fraction of 1/11 and by applying the same procedure on F1, the Minkowski island fractal of second iteration (F2) is obtained.

Figure: 1 Minkowski fractal different iteration

3. ANTENNA STRUCTURE

Antenna structure 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.

4. PERFORMANCE CHARACTERISTICS OF 0TH ITERATION

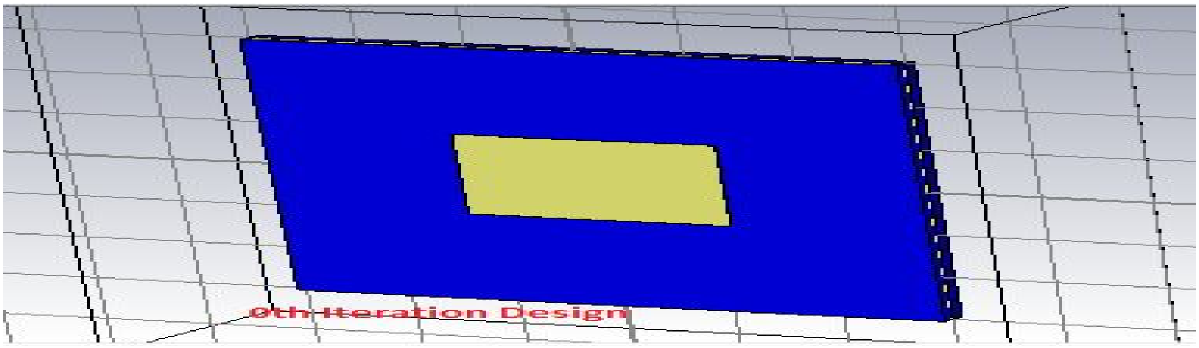


Figure: 2 Zeroth iteration design of Minkowski fractal geometry

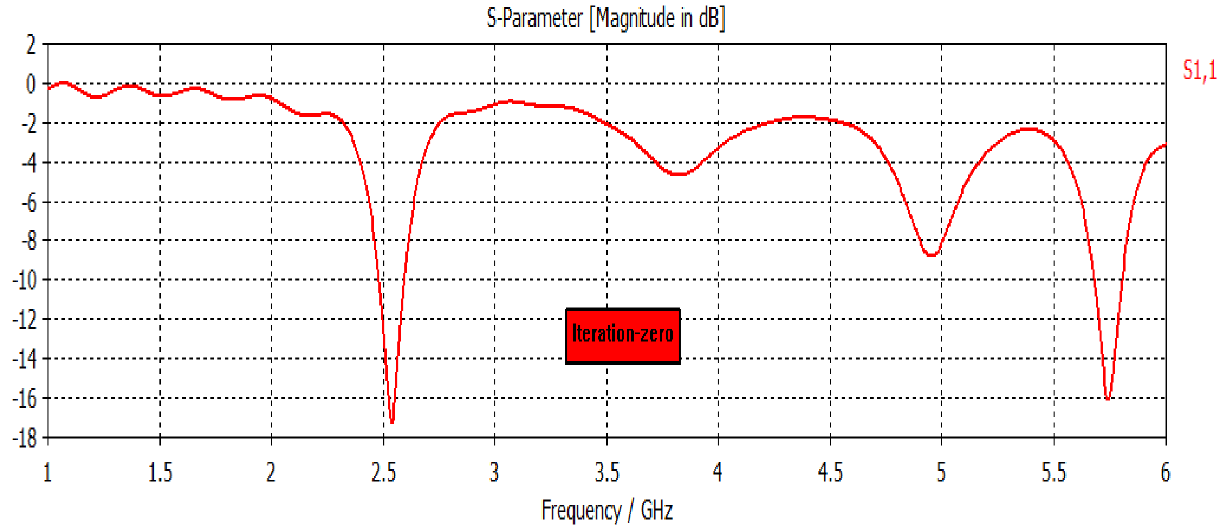


Figure: 3 S11-Parameter at Zeroth iteration of Minkowski fractal geometry.

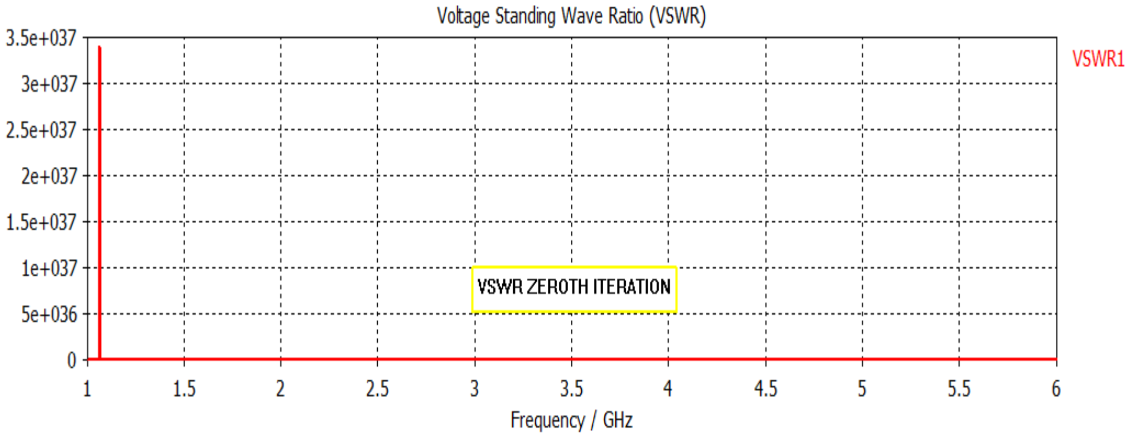
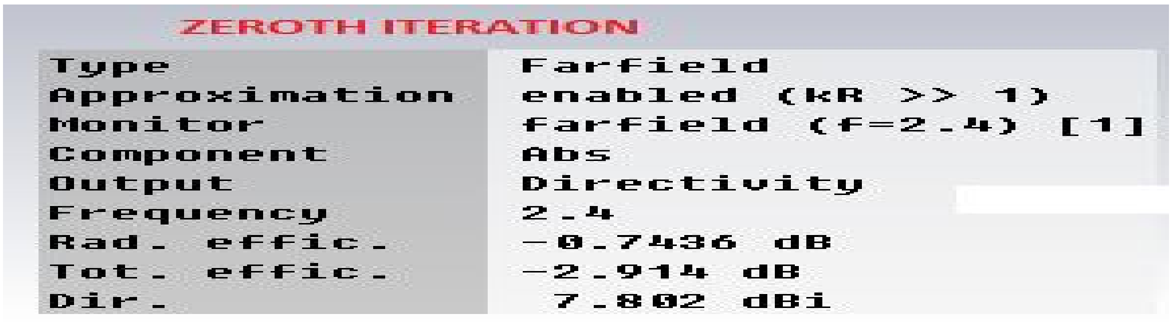


Figure: 4 VSWR at Zeroth iteration of Minkowski fractal geometry.



ZEROTH ITERATION

Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Directivity
Frequency	2.4
Rad. effic.	-0.7436 dB
Tot. effic.	-2.914 dB
Dir.	7.802 dBi

Figure: 5 Directivity at Zeroth iteration of Minkowski fractal geometry.

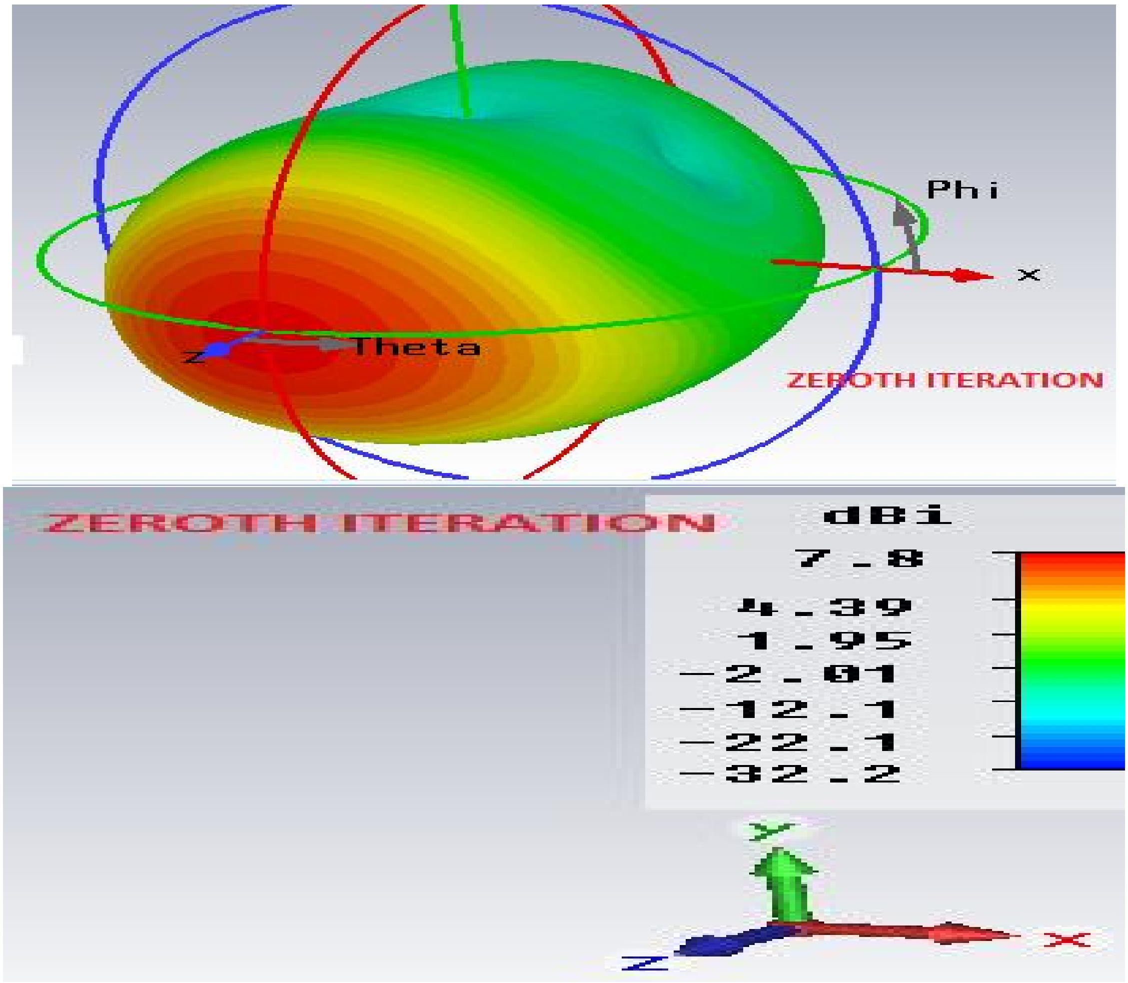
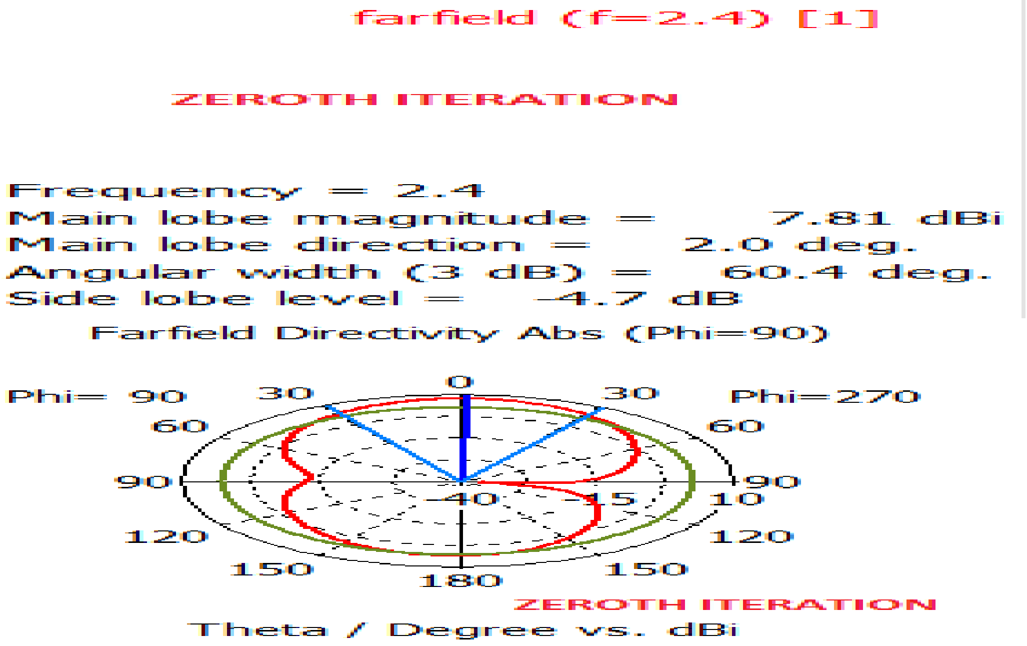
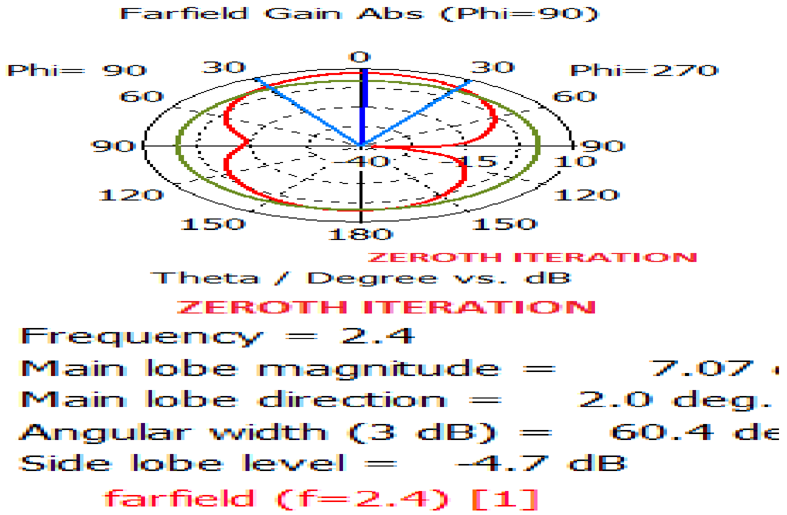


Figure: 6 Radiation Pattern at Zeroth iteration of Minkowski fractal geometry.



Frequency = 2.4
Main lobe magnitude = 7.81 dBi
Main lobe direction = 2.0 deg.
Angular width (3 dB) = 60.4 deg.
Side lobe level = -4.7 dB

Figure: 7 Farfield Directivity at Zeroth iteration of Minkowski fractal geometry.



Frequency = 2.4
Main lobe magnitude = 7.07
Main lobe direction = 2.0 deg.
Angular width (3 dB) = 60.4 de
Side lobe level = -4.7 dB

Figure: 8 Farfield Gain at Zeroth iteration of Minkowski fractal geometry.

6. PERFORMANCE CHARACTERISTICS OF 1ST ITERATION

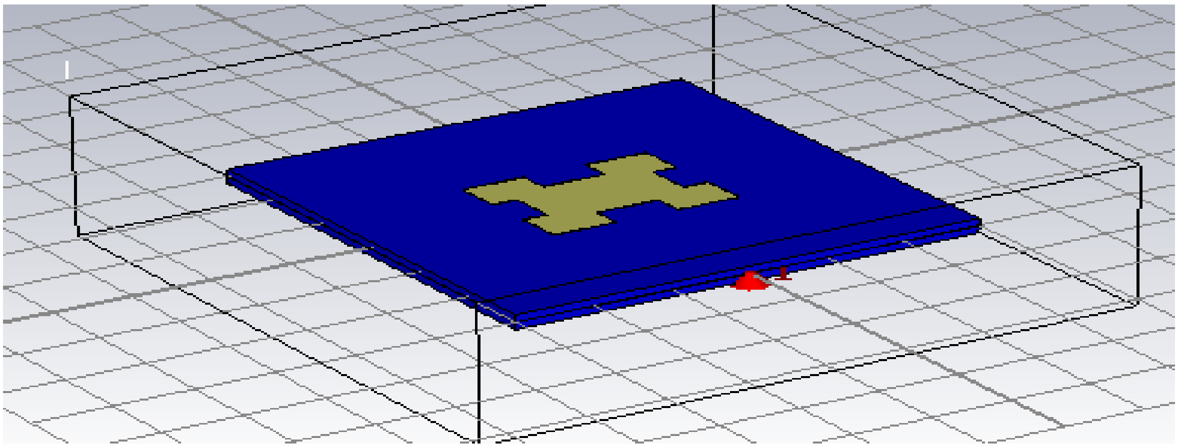


Figure: 9 1st iteration design of Minkowski fractal geometry

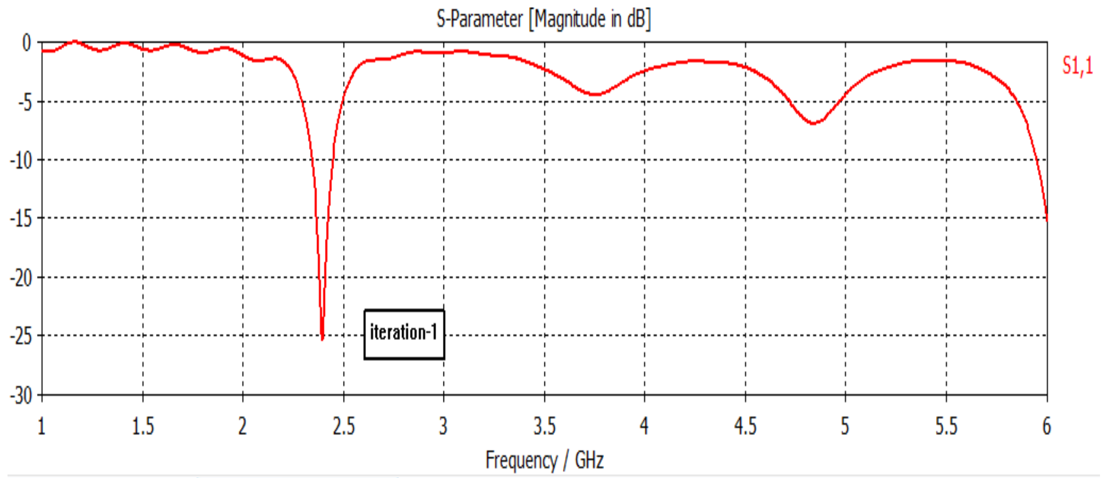


Figure: 10 S11-Parameter at 1st iteration of Minkowski fractal geometry.

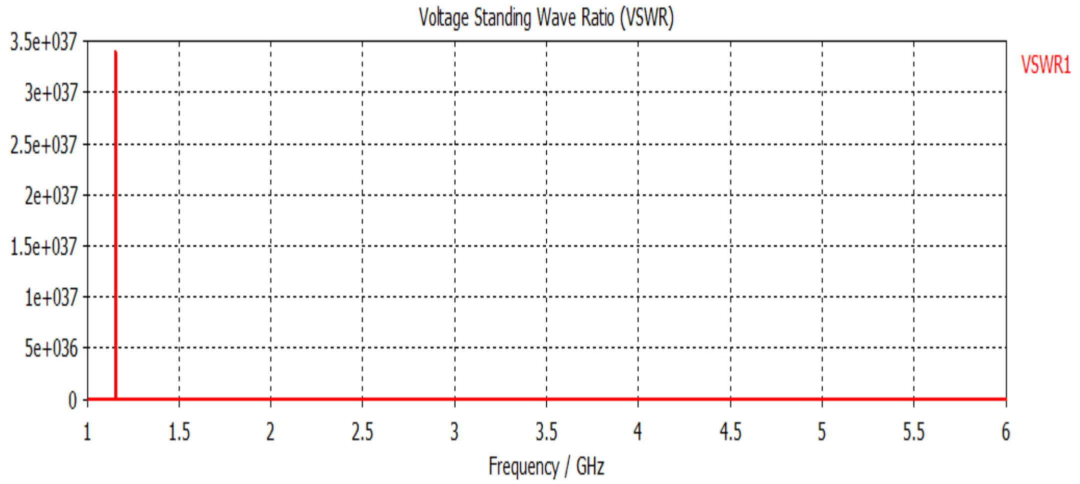


Figure: 11 VSWR 1st iteration of Minkowski fractal geometry.

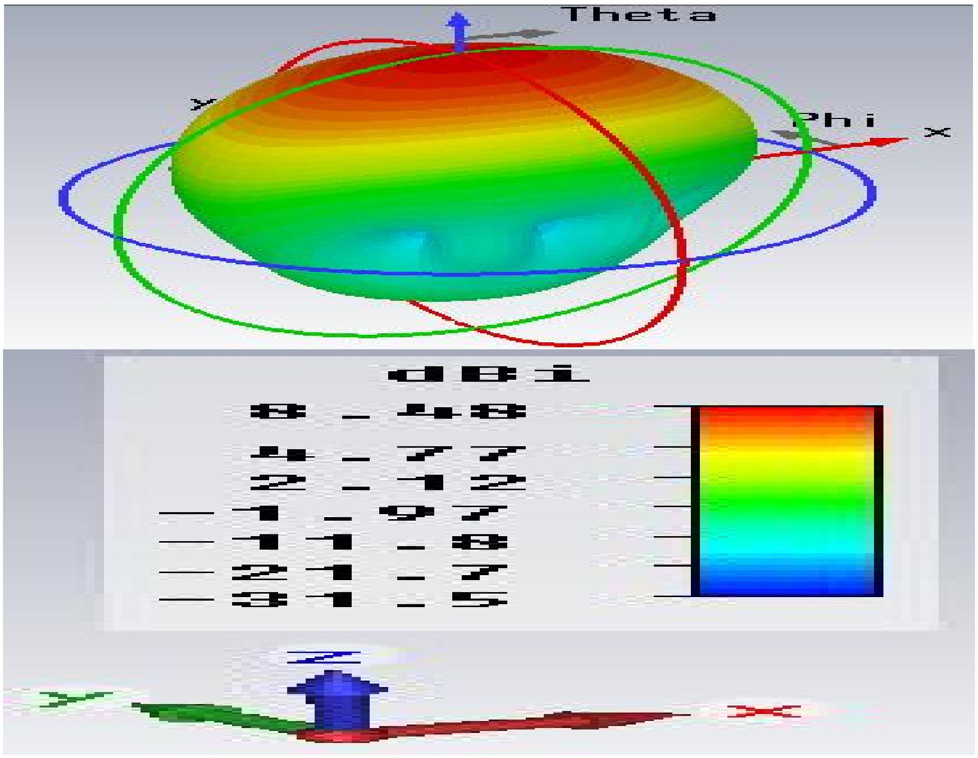
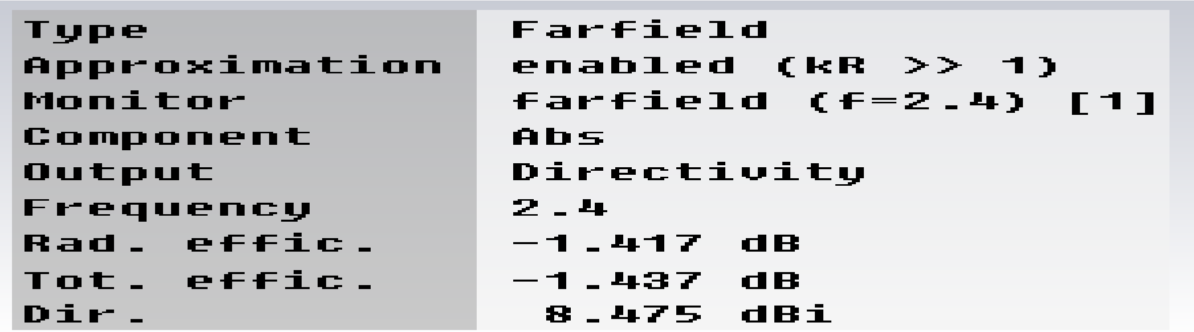


Figure: 12 Radiation Pattern at 1st iteration of Minkowski fractal geometry.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Directivity
Frequency	2.4
Rad. effic.	-1.417 dB
Tot. effic.	-1.437 dB
Dir.	8.475 dBi

Figure: 13 Directivity at 1st iteration of Minkowski fractal geometry.

7. PERFORMANCE CHARACTERISTICS OF 2ND ITERATION

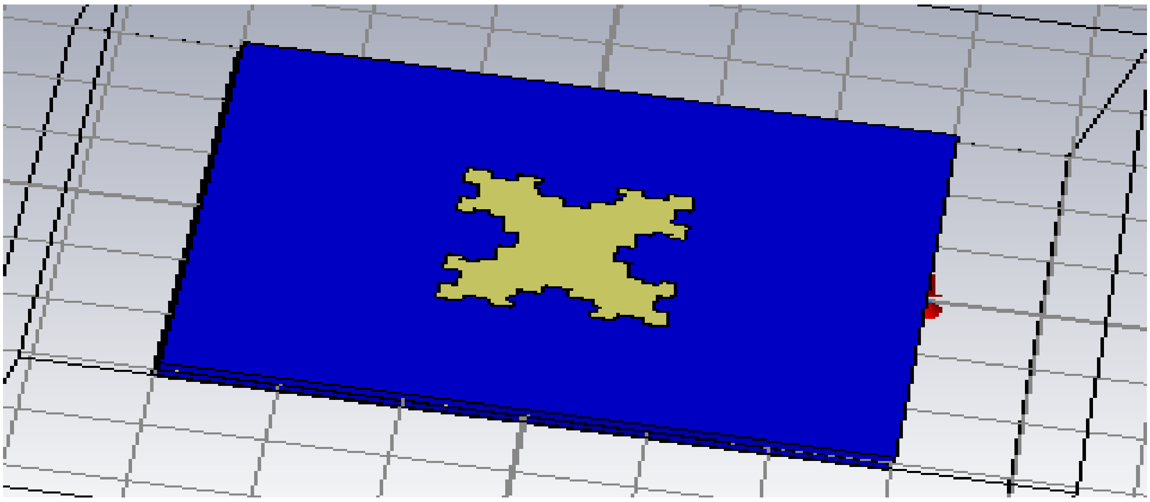


Figure: 14 2nd iteration design of Minkowski fractal geometry.

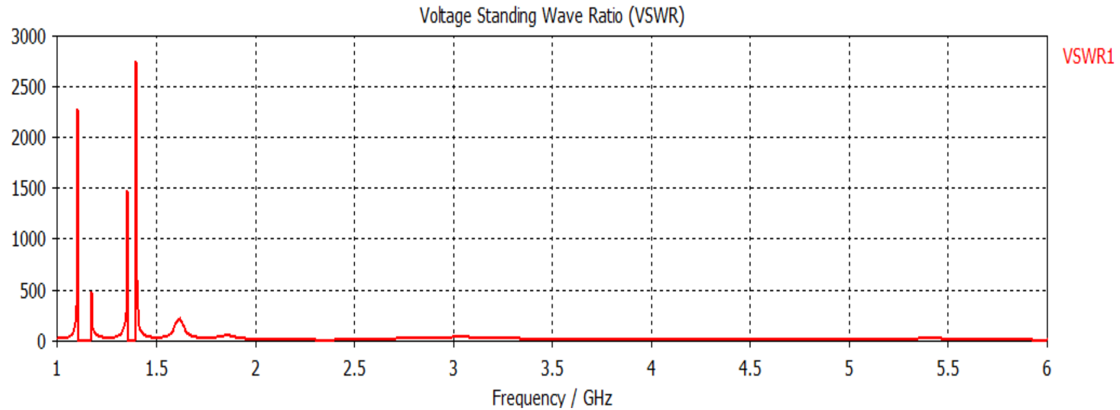


Figure: 15 VSWR 2nd iteration of Minkowski fractal geometry.

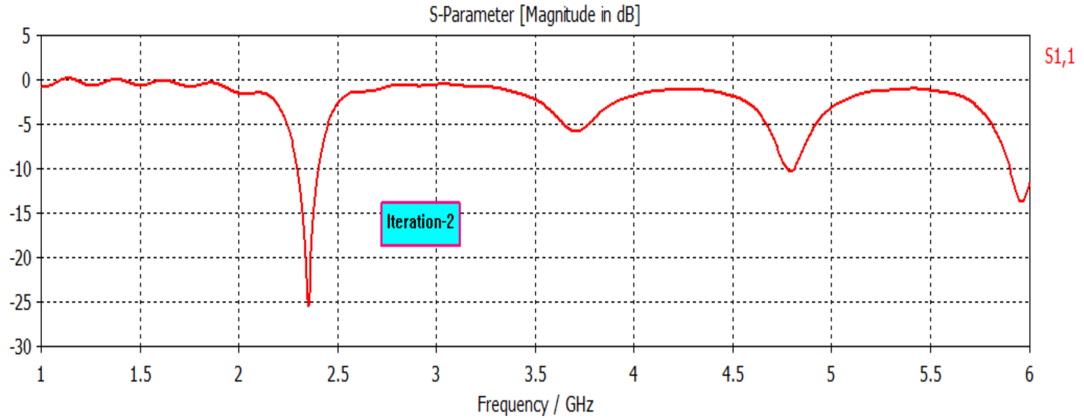


Figure: 16 S11-Parameter at 2nd iteration of Minkowski fractal geometry.

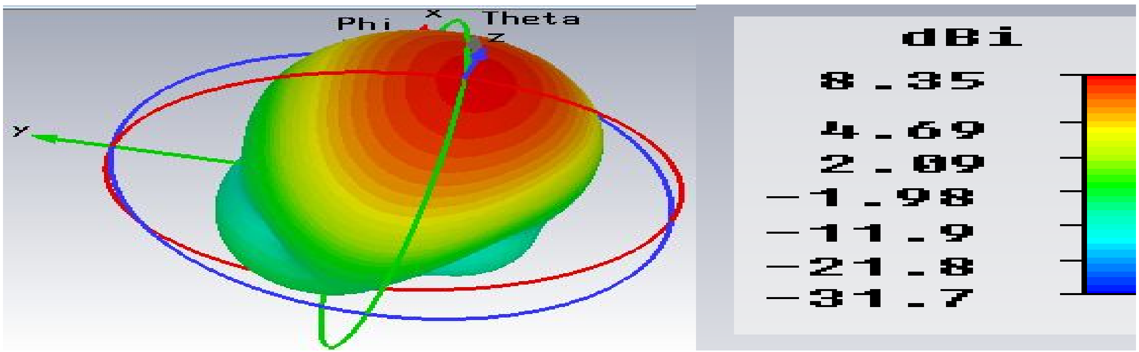
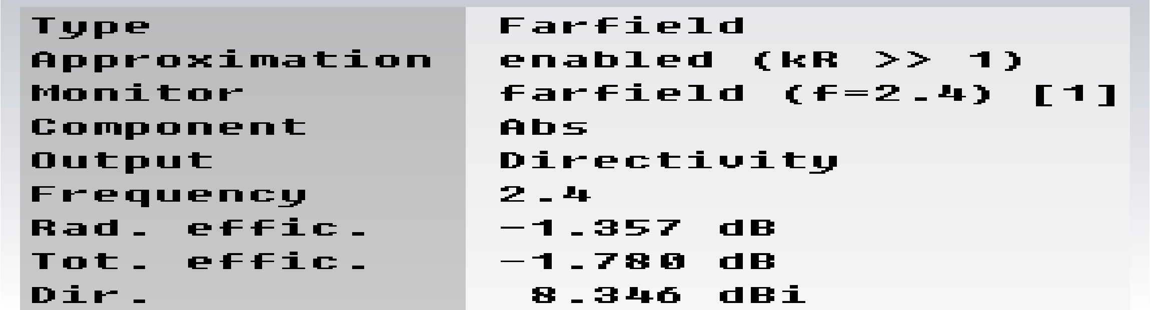


Figure: 17 Radiation Pattern at 2nd iteration of Minkowski fractal geometry.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Directivity
Frequency	2.4
Rad. effic.	-1.357 dB
Tot. effic.	-1.780 dB
Dir.	8.346 dBi

Figure: 18 Directivity at 1st iteration of Minkowski fractal geometry.

8. PERFORMANCE CHARACTERISTICS OF PROPOSED ITERATION

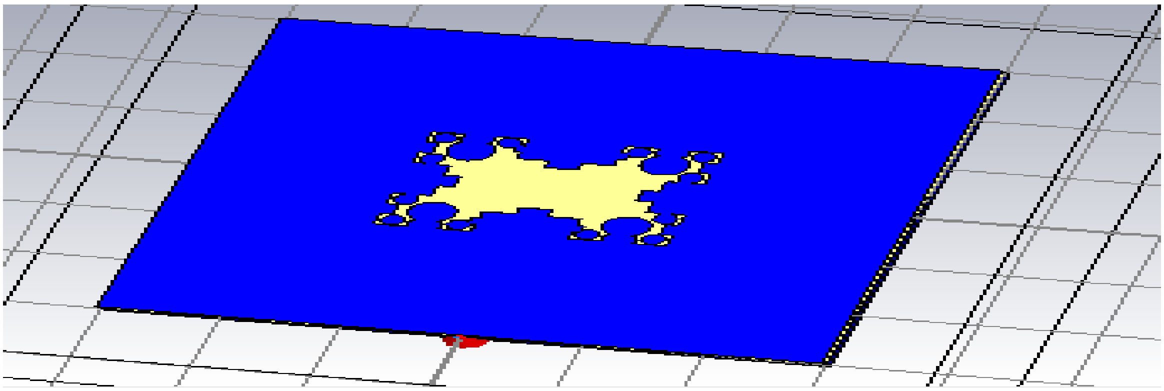


Figure: 19 proposed iteration design of Minkowski fractal geometry.

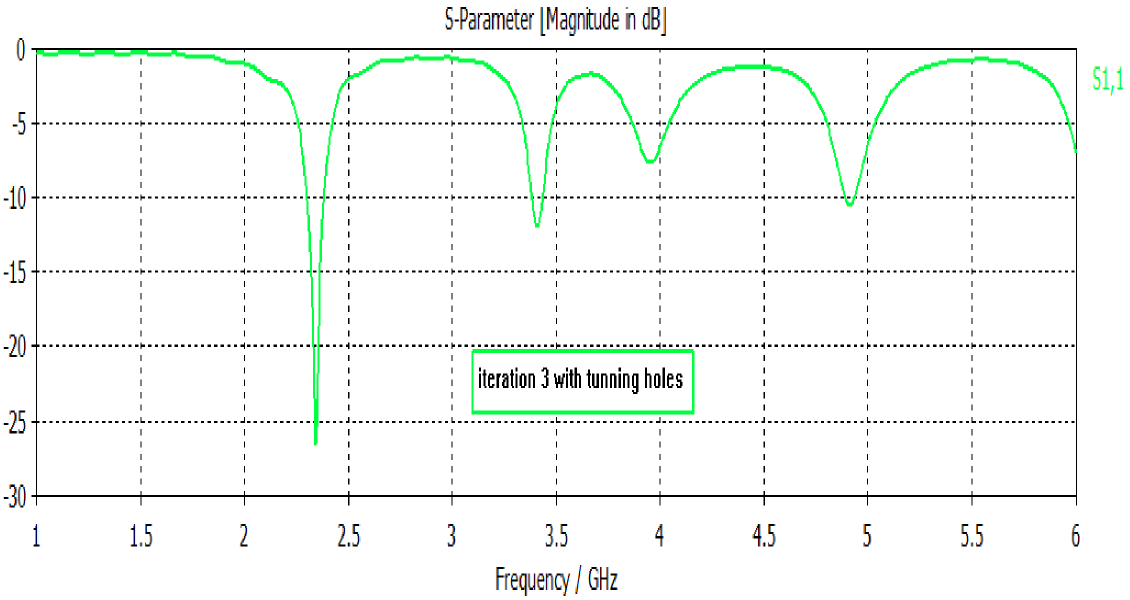


Figure: 20 S11-Parameter at 2nd iteration of Minkowski fractal geometry.

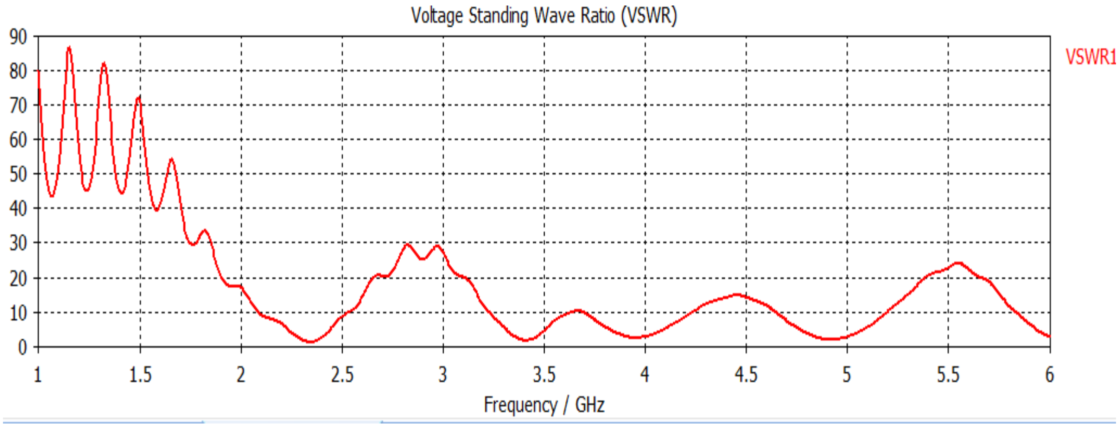


Figure: 21 VSWR at proposed iteration of Minkowski fractal geometry.

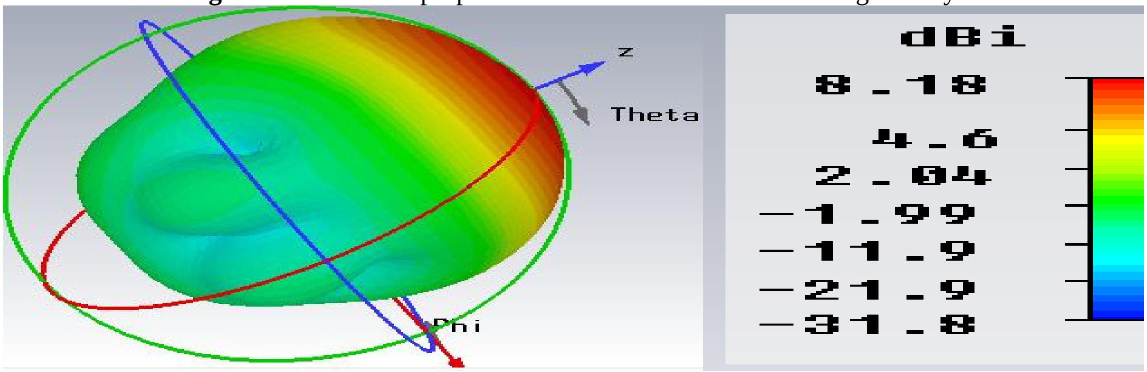
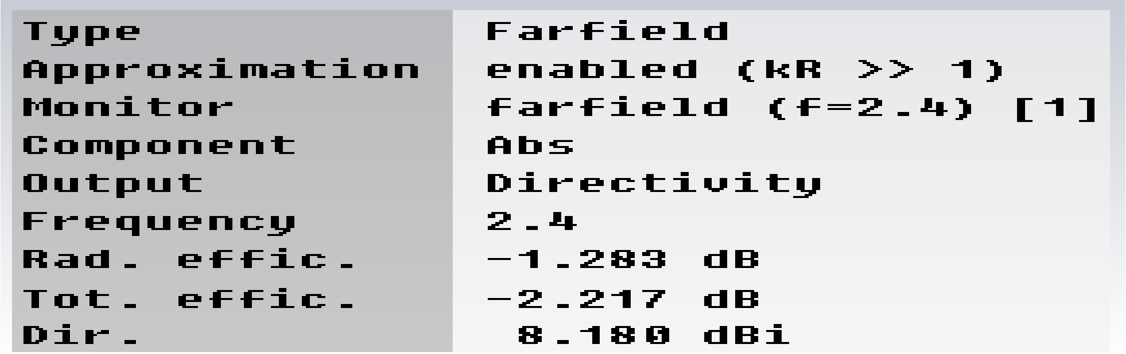


Figure: 22 Radiation Pattern at proposed iteration of Minkowski fractal geometry.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Directivity
Frequency	2.4
Rad. effic.	-1.283 dB
Tot. effic.	-2.217 dB
Dir.	8.180 dBi

Figure: 23 Directivity at proposed iteration of Minkowski fractal geometry.

9.CONCLUSION

In this paper a wearable electro-textile patch antenna is designed by using Minkowski fractal geometries with tuning hole for 0th, 1st and 2nd iterations. In the 1st and 2nd iterations the fractal geometry parameters are fine tuned for WIBRO and GSM 1900 bands. The proposed antenna show a significant size reduction compared to the conventional Microstrip patch antenna. The size of antenna is reduced to 20.212% at second iteration from the predictable patch. A predictable rectangular Microstirp patch antenna has been successfully designed having a central frequency of 2.44 GHz. 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. Hence, the designed antenna is compact enough to be placed in typical wireless devices.

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