Wearable Electro-Textile Microstrip Patch Antenna with Tuning Holes

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ABSTRACT

We investigate the possibilities and properties of the applications of wearable electro-textile antenna by using of Minkowski fractal geometry with tuning holes for the miniaturization of Microstrip patch antenna and compare its performance with those of the usual fractals such as Minkowski fractal geometry without tuning holes. As a result the antenna Miniaturization, maintenance of its gain and increase of its relative frequency bandwidth are achieved 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 GHz to 6 GHz 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. This involve that antenna operating frequency has been reduced considerably with each successive iteration without changing the overall antenna dimensions and thereby miniaturization is achieved. In its first and second iteration antenna designed are optimize and tuned to WIPRO band and in the proposed tuning hole iteration antenna are further miniaturized and can use for multiband frequency in order to make them suitable for GSM 1900 application.

Keywords: Fractal Antenna, Antenna Tuning.

I INTRODUCTION

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 tuning holes we provides multilevel frequency for is different application. The patch antenna with tuning holes gives an augment of impedance bandwidth though the change in material offers and addition of an impedance bandwidth by is appropriate holes.

Dissimilar iterations are also considered to make them suitable for GSM 1900 applications. In this analysis the performance and limitations of these designs in accordance with their separate operating environment are also compared. Antenna properties such as minimized Size simple creation mechanical adaptability and ease are 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.

II FRACTAL LOOPS

Loop antennas are well understood and have been studied using a variety of Euclidean geometry. They have dissimilar limitations however. Two probable fractals fed as Loop antennas are illustrated in Fig.1

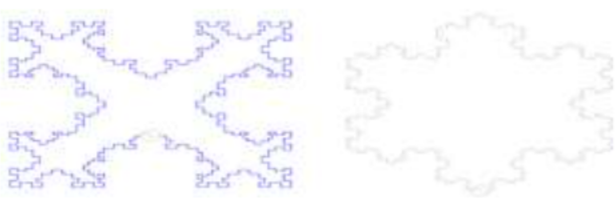


Fig 1: Two possible fractal loop antennas

Fractals loops have the characteristic that the boundary increases to infinity while maintaining the volume in use.

This increase in length and decreases the essential volume in use for the antenna at resonance. For a miniature loop this increase in length progress the input resistance. Microstip patch antenna can be more easily matched to a feeding transmission line by raising the input resistance

III FRACTAL GEOMETRIES

These geometries were in general not needed as unshaped but Mandelbrot discovered that certain special features can be related with them. Several naturally happening phenomena such as lightning are better analyzed with the give support to fractals antenna. One important material goods of all these fractals antenna is indeed their irregular nature. Some examples of fractals are given in Fig.2. So many geometries are infinitely sub-divisible with each separation a copy of the parent. This particular nature of these geometries has led to several exciting features exceptional with Euclidean geometry.

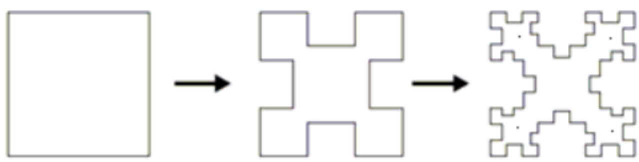


Fig 2: Minkowski Fractal Geometry

IV DESIGN PROCEDURE

In the characteristic design procedure of the Microstrip patch antenna the desired resonant frequency thickness and dielectric constant of the substrate are known or selected originally. In this design of rectangular Microstrip antenna, Flectron dielectric material (ε_r=1.44) with dielectric loss tangent of 0.02 is selected as the substrate with 2.85mm height. Then a microstrip patch antenna that operates at the specified operating frequency f_0 = 2.4 GHz can be designed by the following steps using transmission line model equations. The antenna is existed by the INSET feed away from the center of the patch.

Steps required for calculating width (W) and Length (L) of microstrip antenna

- ✓ Step 1. Initially, select the desired resonant frequency, thickness and dielectric Constant of the substrate.
- ✓ Step 2. Obtain Width (W) of the patch by inserting ε_r and λ_0.
- ✓ Step 3.Obtain Length (L) of the patch after determining ΔL and ε_r.

For the design of a rectangular Microstrip Patch Antenna the three important parameters given bellow.

Basic parameters for design of fractal antenna are given by:

Table1:
Propose Design parameters

Sr.No	Geometry parameter	Value
1	Operating frequency	2.45 GHz
2	Relative dielectric constant	1.44
3	Loss tangen δ	0.02
4	Substrate thickness(h)	2.85mm

(a) Calculation of the width W of antenna which is given by:

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

(b) Calculation of Effective dielectric constant (ε_{reff}): The effective dielectric constant is:

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[\frac{1}{\sqrt{[1+12\frac{h}{W}]}}\right]$$

(c) Calculation of the effective length Leff which is given by:

$$L_{eff}=\frac{C}{2f_0\sqrt{\varepsilon_{reff}}}$$

(d) Calculation of the length extension ΔL which is given by:

$$\Delta L = 0.412*1.58\left[\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)}\right]$$

(e) Calculation of the effective length extension of patch L which is given by:

$L = L_{eff} - 2\,\Delta L$

(f) Calculation of the ground plane dimensions (L_g and W_g):

V ANTENNA STRUCTURE

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 tructure is fed by an aperture using microstrip line. The microstrip feeder line dimensions are taken for 50ohm characteristic impedance.

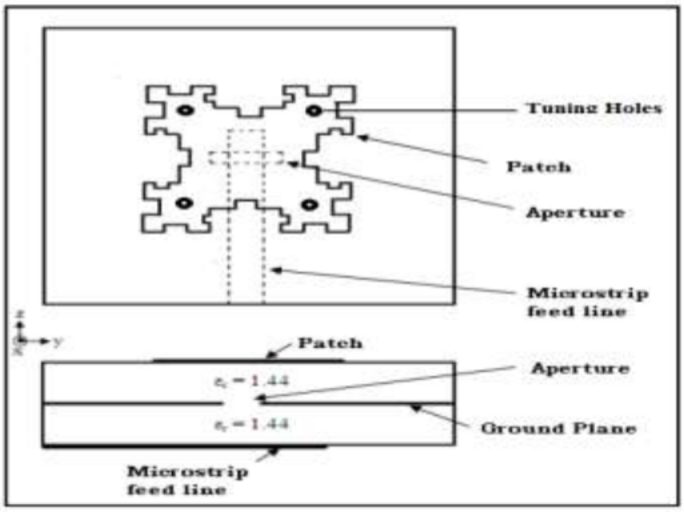


Fig 3: Structure of antenna with tuning holes

VI PERFORMANCE CHARACTERISTICS

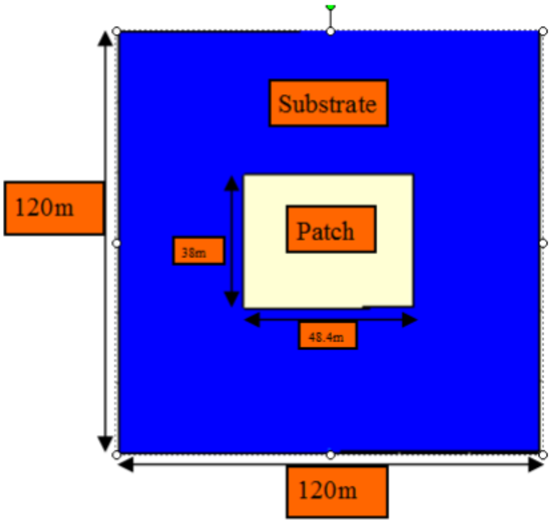


Fig 4: 0th Iteration design of Minkowski fractal geometry

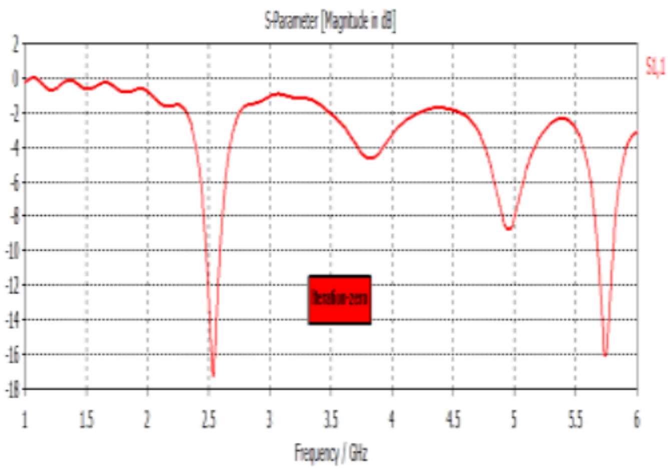
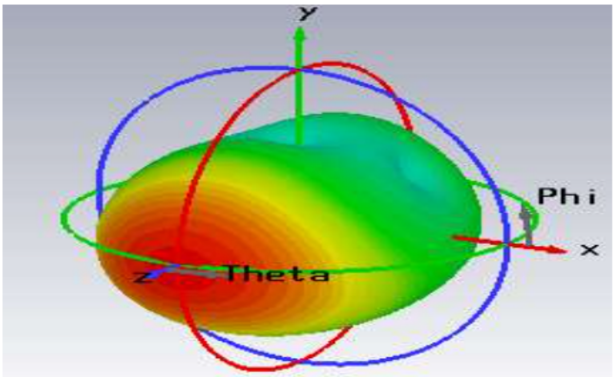
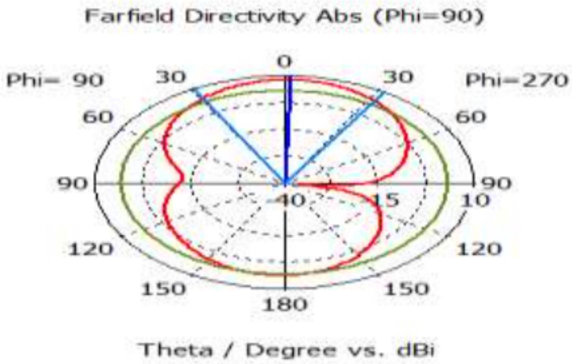


Fig 5: 0th Iteration S11-Parameter at of Minkowski Fractal geometry



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

Fig 6: 0th Iteration Radiation patterns of antenna



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

Fig 7: Farfield Directivity polar result of Radiation Pattern at 0th iteration of Minkowski fractal geometry.

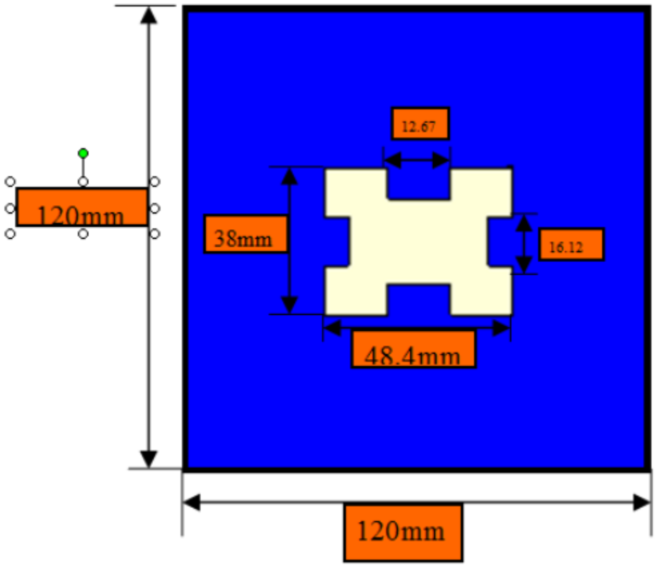


Fig 8: 1st Iteration design of Minkowski fractal geometry

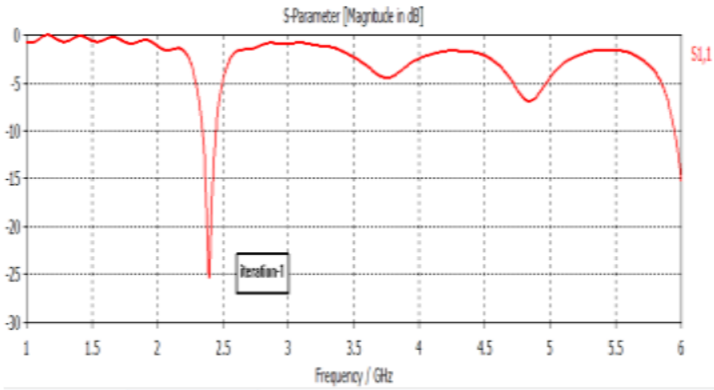
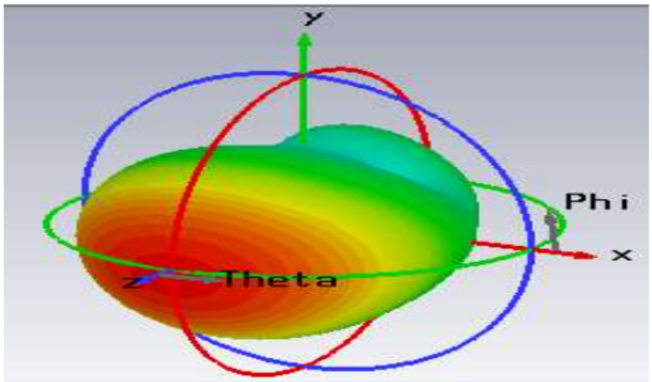


Fig 9: S11-Parameter at 1st iteration of Minkowski fractal geometry



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

Fig 10: 1st Iteration Radiation patterns of antenna

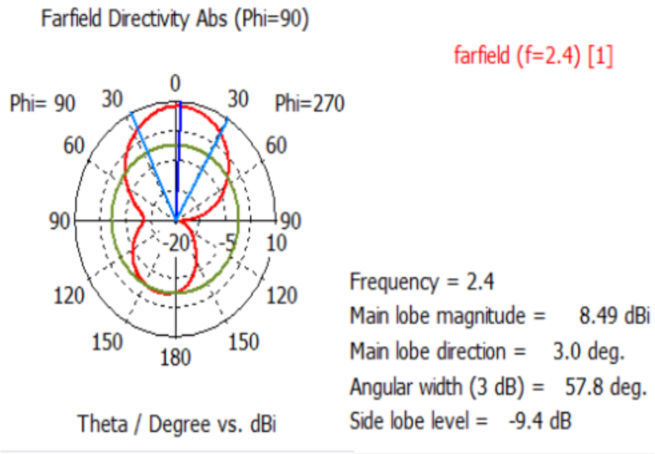


Fig 11: Farfield Directivity polar result of Radiation Pattern at 1st iteration of Minkowski fractal geometry.

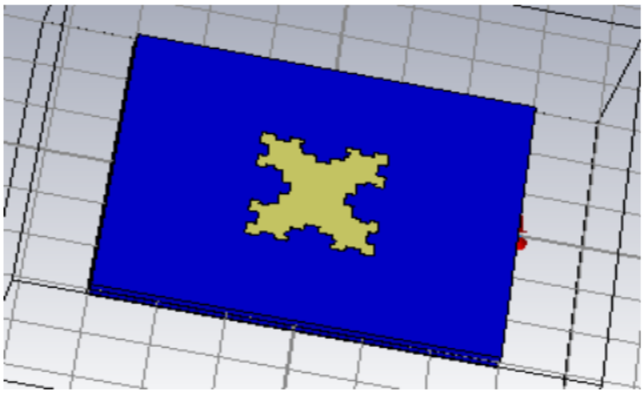


Fig 12: 2nd Iteration design of Minkowski fractal geometry

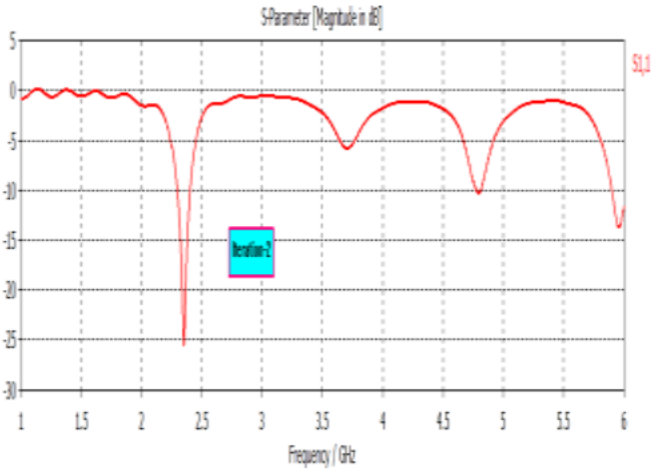
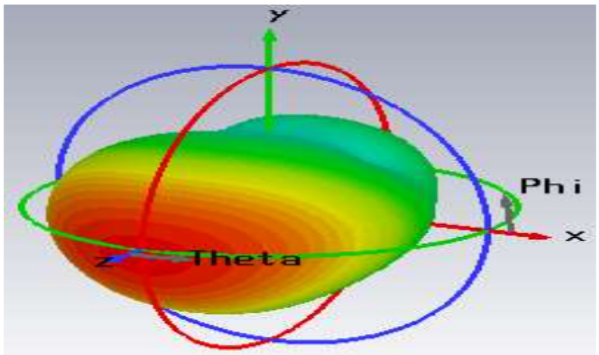


Fig 13: S11-Parameter at 2nd iteration of Minkowski fractal geometry



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

Fig 14: Radiation patterns of 2nd Iteration antenna

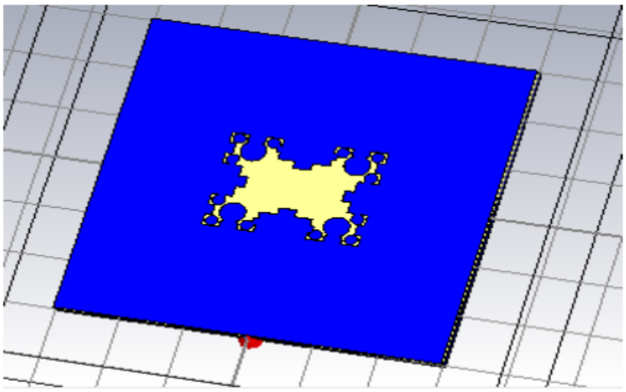


Fig 15: Proposed iteration design of Minkowski fractal geometry.

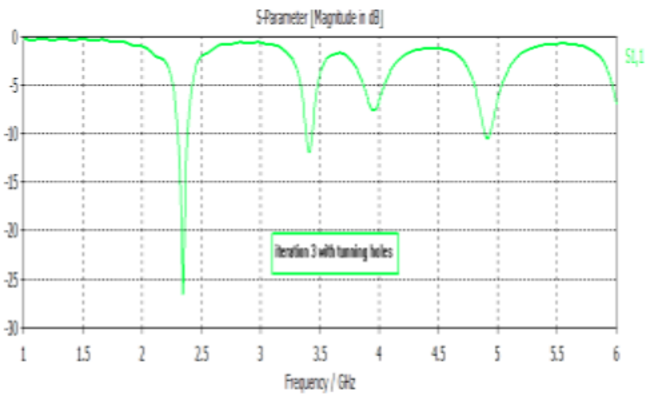


Fig 16: S11-Parameter at Proposed iteration of kowski fractal geometry

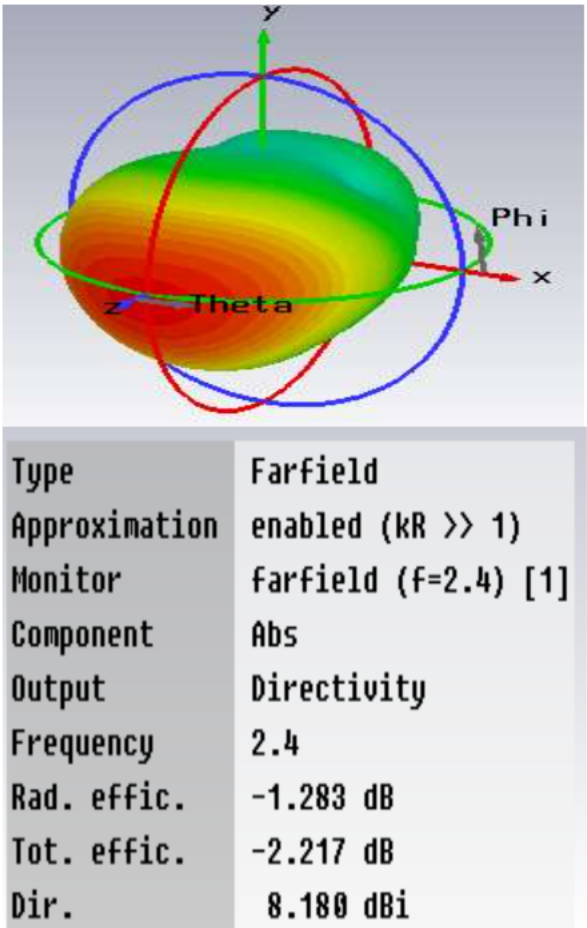


Fig17: Radiation patterns of proposed antenna

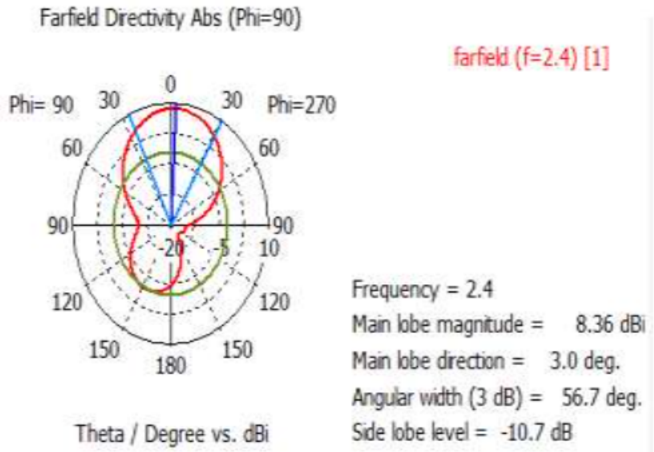


Fig 18: Return loss characteristic of proposed antenna for all iterations.

VII COMPARISON OF PROPOSED ANTENNA RESULT.

Here we provide a comparison of zelt antenna result and Flectron antenna result with different iterations.

Table 2:
Comparison of Proposed Antenna Result

Parameters	Zelt-Iteration No.			Flectron –Iteration No			
	0^{th}	1^{st}	2^{nd}	0^{th}	1^{st}	2^{nd}	pro-posed
Directivity (dBi)	8.6	8.4	7.7	7.81	8.46	8.33	8.15
Efficiency (%)	76.0	72.1	45.6	51	71	66	60
3 dB beam width (E)	73^0	75.1^0	76.2^0	94.7^0	44.8^0	85.4^0	102.2^0

VIII 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 conventional patch. A conventional 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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