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Design of Fractal Antenna for Ultra Wide Band Applications

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***Abstract*— Ultra Wide band pattern antenna with hexagonal fractal geometry has been planned in this paper. The proposed antenna is coaxial line fed and its structure relies on geometry wherever the resonance frequency of antenna is lowered by applying iteration techniques. Analysis of pattern antenna is finished by exploitation software system named CST Microwave Studio Suite. This antenna has low profile, is light-weight and simple to be fabricated.It is capable of successfully possessing multiband and broadband characteristics. Results of simulations show that the planned antenna has superb performance in radiation pattern and bandwidth.**

Keywords—Fractal geometry; wideband; multiband; fractional bandwidth.

I. INTRODUCTION

In modern wireless communication systems, antennas with wider bandwidth, multiband and low profile characteristics are in great demand for both commercial and military applications. This has initiated research on antennas in various directions. Fractal geometry is a very good solution to fabricate these antennas.This causes widespread researches about fractal antennas recently.This paper illustrates a multiband antenna is by applying fractal shape into the antenna geometry.

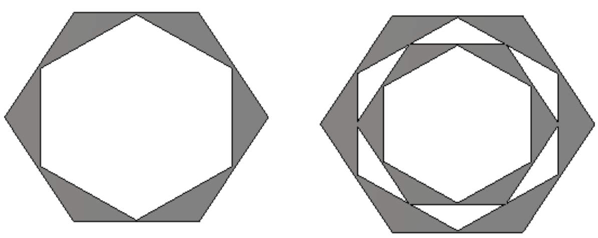
Fractals are highly complicated shapes and having many corners, that these discontinuities increase bandwidth and effective radiation of antennas. Three-sided and four-sided structures have been already used by many UWB antennas in their construction.Hence Fractal UWB antenna with hexagon as base geometry is being proposed. The fractal antenna's geometrical properties of self-similarity and space filling nature lead to curves that can fit into compact physical space.

II. PAST WORKS

Due to the popularity of fractal geometry and great demand for ultra wideband characteristics many researchers have contributed towards the development of these fractal antennas. Javad Rohani and Abolfazl Azari [2] have achieved an ultra wideband antenna by applying a Koch fractal geometry to a wire square loop antenna. Modelling and simulation is performed via SuperNEC electromag-netic simulator. Also, optimization is performed via GAO (genetic algorithm optimizer). The researchers finally concluded that it is an ultra wideband antenna and it is operational in frequencies between 100Mhz to 10 Ghz because in these frequencies approximately $S11 < 10$ dB. N.A Saidatul, A.A.H. Azremi, R.B. Ahmad, P.J Soh, F.Malek [3] proposed the fractal PIFA(Planar Inverted F Antenna) with bandwidth enhancement for mobile phone applications. The antenna achieved the GSM, UMTS and HiperLan frequency with -6 dB return loss and has almost omnidirectional radiation pattern. Another popular fractal geometry implementation was done by A. Azari and J,Rowhani[4].They used the hexagon as a base geometry. They analyzed the antenna using Microwave Office software. This antenna was able to achieve much more wideband and multiband characteristics. The antenna was found to be broadband and applied in all frequencies (0.1 GHz–24 GHz) since in these frequencies the S11 were found to be less than −10 dB.

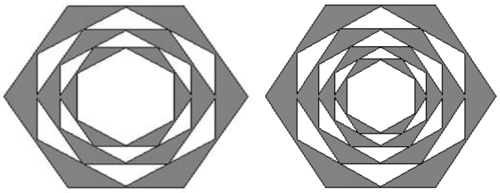
III. PROPOSED ANTENNA DESIGN

Fractal design has two components (i)Initiator (0th stage): the basic shape of the geometry. (ii)Generator: the shape which gets repeated in a pattern on the initiator in subsequent stages of different dimensions. In the proposed design, the hexagon is chosen as base shape or initiator shape. The generator shape is then taken to be the different scaled version of the base shape as shown in the figure below:



(a)0th iteration (b)1st iteration

Each side of the base hexagon was taken to be 30mm. The substrate chosen was Rogers RT 5870 with dielectric constant or relative permittivity of $\varepsilon_r = 2.33$ with dimensions 70x70mm and sustrate height 2mm. With proper scaling factor, two more iterations were taken as shown in the figure below. Higher iterations were avoided because they didn't contribute any significant changes in the antenna behaviour and radiation pattern.



(c)2nd iteration (d)3rd iteration

Fig1.Different iterations of the proposed antenna.

The ground plane was initially taken to be 70mmx70mm but the S11 results analysis were very poor.The feed was given at a length of 28mm along x-axes and width of 12mm along y-axes from leftmost down edge of outer hexagon. The ground plane width was therefore suitably reduced to achieve better results and performance. The length of the ground plane was taken to be same 70mm. The reduction of the ground plane has resulted in lowering of the copper losses associated with the conducting ground plane.

IV. RESULTS AND DISCUSSIONS

The comparison of results with full ground plane and reduced ground plane is shown in figure 2 below:

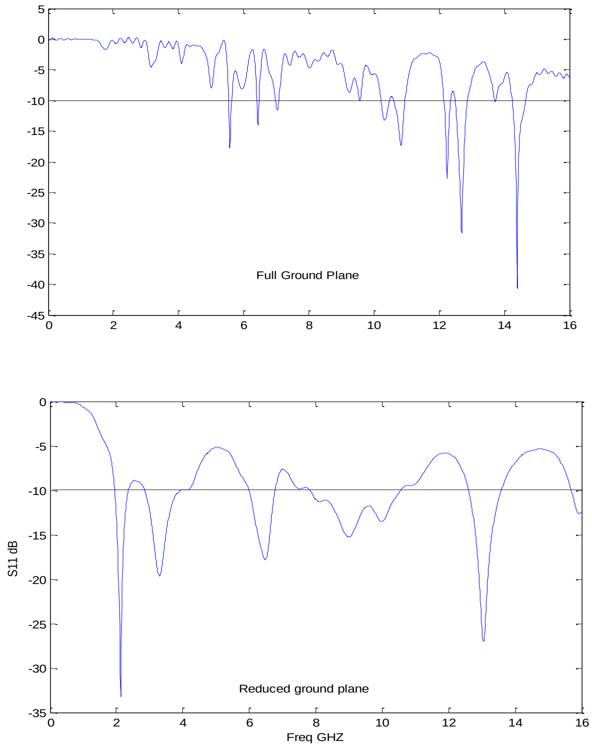
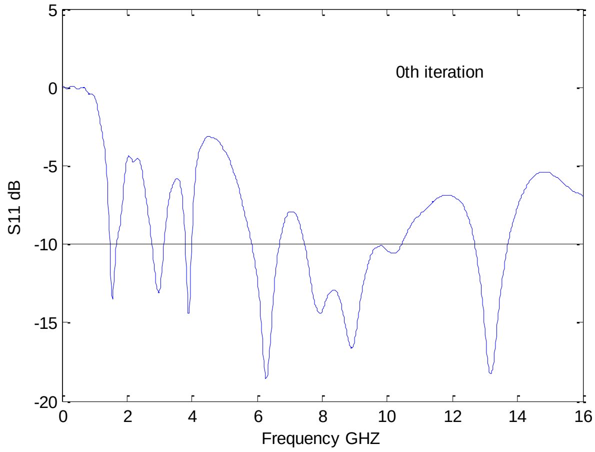
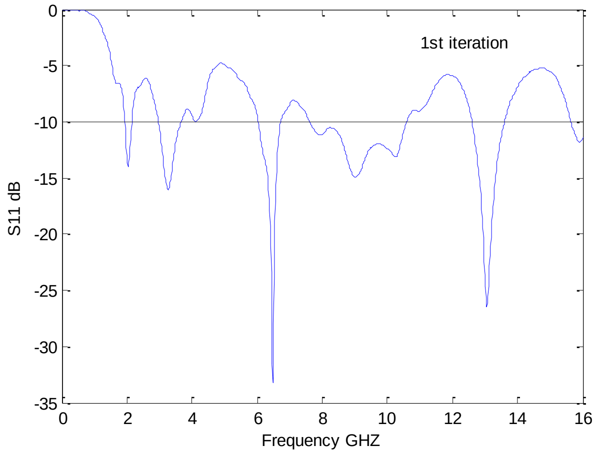


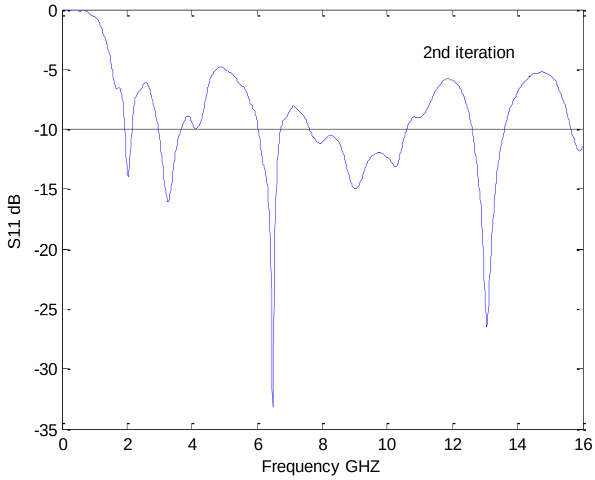
Fig 2.Comparison of results with full ground plane and reduced ground plane.



(a)0th iteration results

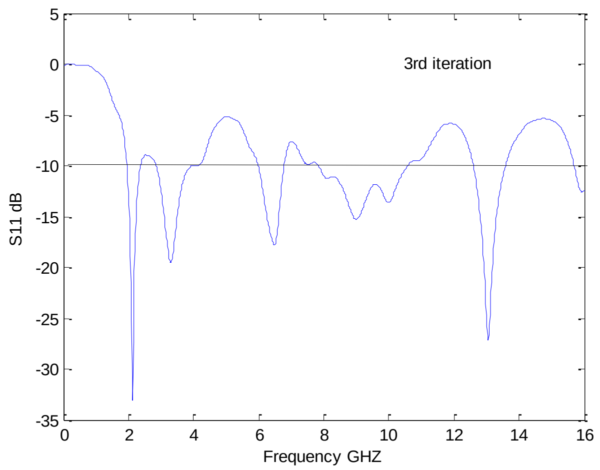


(b)2nd iteration results



(c)3rd iteration results

Figure 2 (a),(b),(c),(d) shows the S11 results for all the iterations. As can be seen lower frequency results have started to improve with higher iterations along with fractional bandwidth. The comparative study of these iterations with maximum bandwidth and fractional bandwidth obtained is shown in table 1.



(d)3rd iteration results

Figure 2.S11 results for all iterations

Iteration	Max bandwidth	Fractional bandwidth
0th	2.97 Ghz	23.43%
1st	2.99 Ghz	32.83%
2nd	2.99 Ghz	32.98%
3rd	2.75 Ghz	29.89%

Table 1.Comparison of different iterations

The fractional bandwidth for the 3rd iteration is although lower than previous iterations but the lower frequency bands have improved. As fractional bandwidth is a measure of how much ultra wide band an antenna actually is, its higher value is preferred. So for this reason rectangular slots were added in the existing antenna. A midslot and two small slots were added at equidistant from the midslot. The length and width taken along x-axes and y-axes respectively and were optimized to give best results. The final antenna so obtained showed excellent wideband and multiband charactersitics. The final S11 results of the fully optimized antenna is shown in figure 3. The different bands obtained were (i)1.90-4.2 Ghz, (ii)5.88-11.07 Ghz, (iii)12.72-15.2 Ghz thus this antenna is covering the GSM 1800 Mhz band, 2.4 Ghz Bluetooth,3000 Mhz 3G, and Wi –Max band in addition to satellite applications bands at higher frequencies.The fractional bandwidth came out to be 75.40%..The radiation pattern shown in figure 3 obtained at frequency 8.5 Ghz clearly indicated that this antenna was working as an omnidirectional antenna with main lobe magnitude 6.9 dBi in y-direction with theta at 91 degrees.The 3 dB beamwidth came out to be 59.8 degrees.

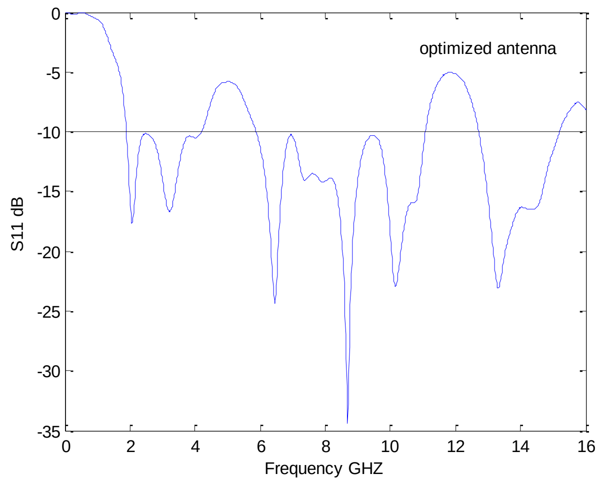


Figure 3. S11 results of optimized antenna

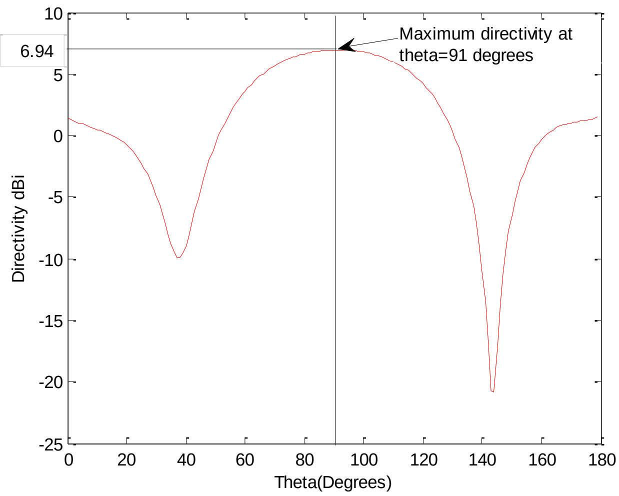


Figure 4. Theta vs dBi

V. CONCLUSION

A fractal ultra wide band antenna with wideband and multiband charcteristics has been studied. Different iteration were also discussed and corresponding results were also analyzed. A significant improvement in gain was achieved with each iteration.

More of the lower frequencies can be brought into the bandwidth, thus increasing the overall bandwidth for both antennas. The fractional bandwidth can then increase to 144.8% in the single slot antenna case and to 152.7% in the 3-slot antenna case. We intend to try to increase the size of base geometry and number of iterations by scaling it to more optimum configuration.

VI. Acknowledgements

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