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DESIGN OF MODIFIED FRACTAL MICROSTRIP PATCH ANTENNA FOR MULTIBAND APPLICATIONS

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Abstract

In this paper a modified fractal microstrip patch antenna is designed and simulated. The three iterative forms of the designed antennas is considered. The designed antennas have the multiband wireless applications such as IEEE 802.11 a (5 GHz), b (2.4 GHz) g (2.4GHz) and n (2.4/5 GHz). The designed antennas also show the wide band behavior at different resonating frequencies. The radiation pattern of the designed antennas is omnidirectional in all the fractal geometries. The band width at the resonating frequency of 2.4 GHz is nearly one GHz with a return loss of - 11 dB. The return loss achieved at 3.6 GHz is 13.5 dB and at 5 GHz is 16 dB. The antenna also shows the wide band behavior between 5 GHz and 6 GHz. The simulation of these antennas is done using HFSS.

Keywords: Fractal, Microstrip, Multiband Antenna.

Introduction

Modern telecommunication systems require antennas with wider bandwidths and smaller dimensions than conventionally possible. This has initiated antenna research in various directions, one of which is by using fractal shaped antenna elements. In recent years several fractal geometries have been introduced for antenna applications with varying degrees of success in improving antenna characteristics. Some of these geometries have been particularly useful in reducing the size of the antenna, while other designs aim at incorporating multiband characteristics. Yet no significant progress has been made in corroborating fractal properties of these geometries with characteristics of antennas. The research work presented here is primarily intended to analyze geometrical features of fractals that influence the performance of antennas using them. Several antenna configurations based on fractal geometries have been reported in recent years. These are low profile antennas with moderate gain and can be made operative at multiple frequency bands and hence are multi-functional. In this work the multi-band (multifunctional) aspect of antenna designs are explored further with special emphasis on identifying fractal properties that impact antenna multi-band characteristics. Antennas with reduced size have been obtained using Hilbert curve fractal geometry. Furthermore, design equations for these antennas are obtained in terms of its geometrical parameters such as fractal dimension. Antenna properties have also been linked to fractal dimension of the geometry. The primary motivation of fractal antenna engineering is to extend antenna design and synthesis concepts beyond Euclidean geometry. In this context, the use of fractals in antenna array synthesis and fractal shaped antenna elements have been studied. Obtaining special antenna characteristics by using a fractal distribution of elements is the main objective of the study on fractal antenna arrays. It is widely known that properties of antenna arrays are determined by their distribution rather than the properties of individual elements. Since the array spacing (distance between elements) depends on the frequency of operation, most of the conventional antenna array designs are band-limited. Self-similar arrays have frequency independent multi-band characteristics. Fractal and random fractal arrays have been found to have several novel features. Variation in fractal dimension of the array distribution has been found to have effects on radiation characteristics of such antenna arrays. The uses of Random fractals reduce the fractal dimension, which leads to a better control of side lobes. Synthesizing fractal radiation patterns has also been explored. It has been found that the current distribution on the array affects the fractal dimension of the radiation pattern. It may be concluded that fractal properties such as self-similarity and dimension play a key role in the design of such arrays

Modified Fractal Microstrip Antenna Design

In these work three iterations of the rectangular patch antenna is considered. The designed structure is given the name modified fractal because aoctangon shape slot is made in the rectangular patch. Initially the rectangular patch antenna is designed at 2.4 GHz. The dielectric substrate used for the design is FR4 / glass epoxy of dielectric

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constant 4.4, loss tangent of 0.02 and the height of the dielectric is 1.6 mm. The following formulas are used for calculating the width and length of the microstrip patch antenna.

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

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left(1 + \frac{12h}{w}\right)^{-(1/2)} \quad (2)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

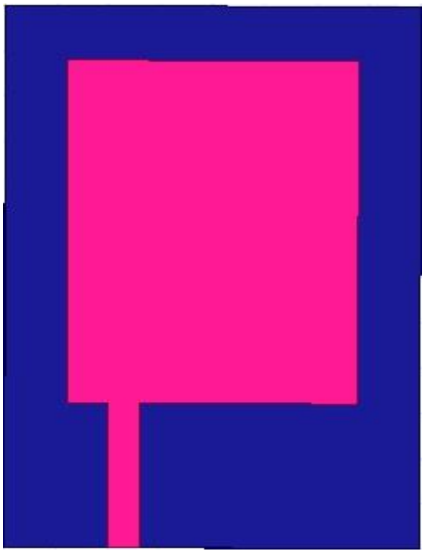
$$L = L_{eff} - 2\Delta L \quad (5)$$

Here in the formulas
c = Velocity of light in free space
f_0=Operating resonant frequency
ε_r= Relative dielectric constant
ε_{reff}=Effective dielectric constant of the substrate
h= Height of the substrate
w = Width of the substrate

The calculated width is 38 mm and the length is 28 mm. The microstrip feed line technique is used for the feeding of all the antennas. The width of themicrosrrip feed line is calculated for the 50 ohm is 3.05mm.

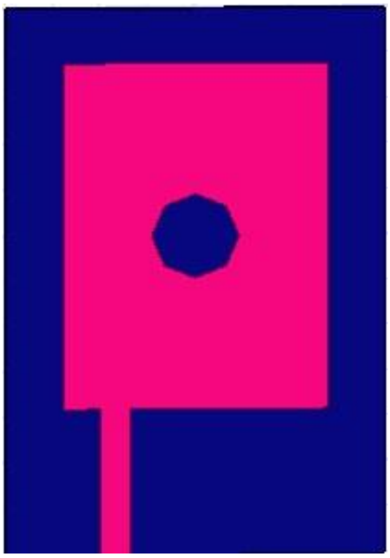
$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{eff}\left[\frac{W}{H}+1.393+\frac{2}{3}ln\left(\frac{W}{H}+1.444\right)\right]}} \quad (6)$$

The designed antennas are shown in figure 1.

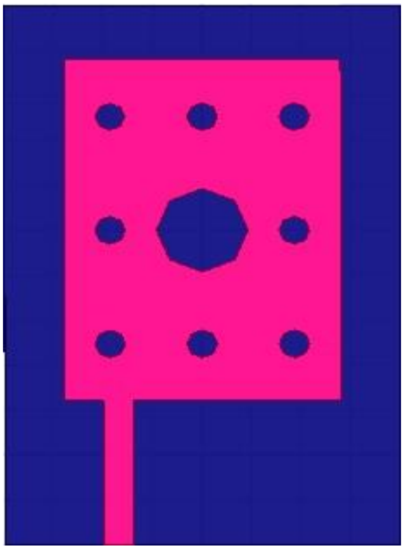


(a)

(1)
(3)
(4)



(b)



(c)

Figure 1: Modified Fractal Microstrip (a) Base Antenna (b) First Iterative Antenna (c) Second Iterative Antenna

The Feeding is done near to the edge so that higher order mode is excited along with the TM_{01} mode at the 2.4 GHz. The three iteration are made in length and three iterations are made in the width 38 mm in rectangular patch. So, the entire rectangular patch consists of the 9 rectangular segments of dimensions 9.33 mm and 12.66 mm as shown in fig 1(b). In the first iterations an octagonal slot is cutted from the central rectangular patch. In the second iterative form additional nine octagon slot are made in rectangular patch. The addition nine octagon slots are made from the nine additional rectangles of dimension 3.11 mm1 and 4.22 mm.

Results and Discussions

The return loss of all the three designed antennas are simulated and discussed. The S_{11}(dB) Vs frequency curve of the base form of rectangular patch antenna is shown in figure 2.

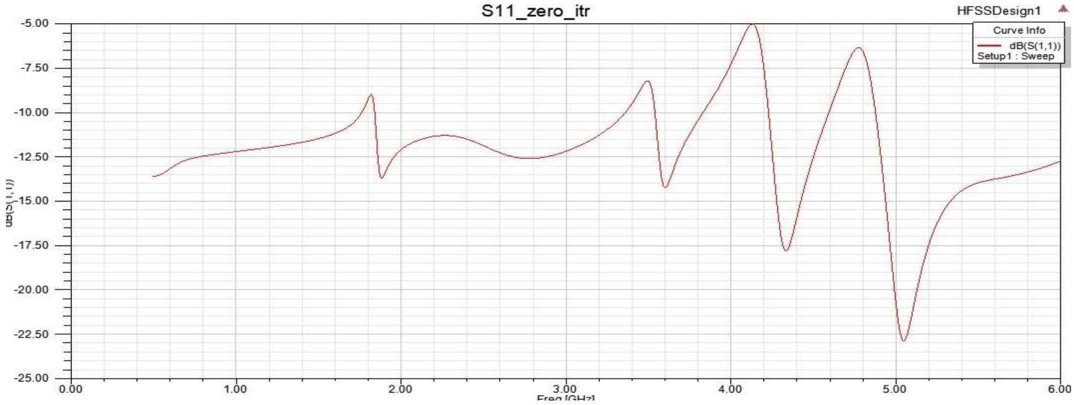


Figure 2: S11Vs Frequency Curve for Base Antenna

The above curve shows that the antenna is resonating at the multiband frequency and also shows the wideband behavior at the different frequency. The S_{11}(dB) Vs frequency curve of the base form of rectangular patch antenna is shown in figure 3.

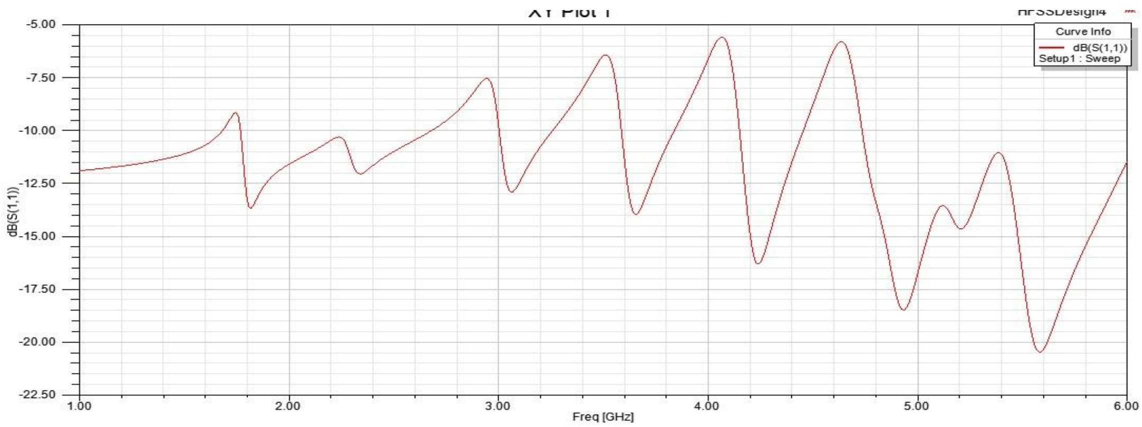


Figure 3: S11Vs Frequency Curve for First Iterative Antenna

It is shown from the above curve that the no. of resonating frequency band increases in the first iterative antenna as compared to base antenna. As the frequency increases the wide band behavior also increases in the first iterative antenna as compared to base antenna. The second iterative form of the modified fractal antenna is shown in figure 4.

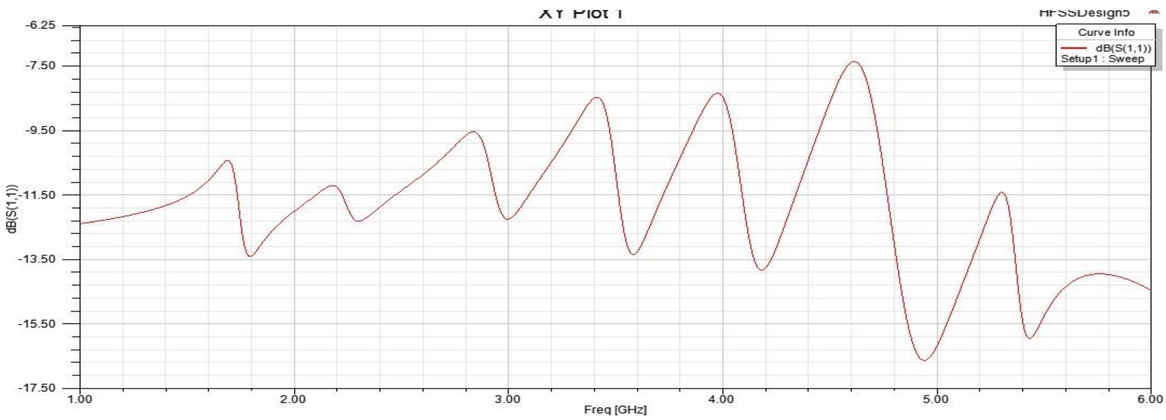
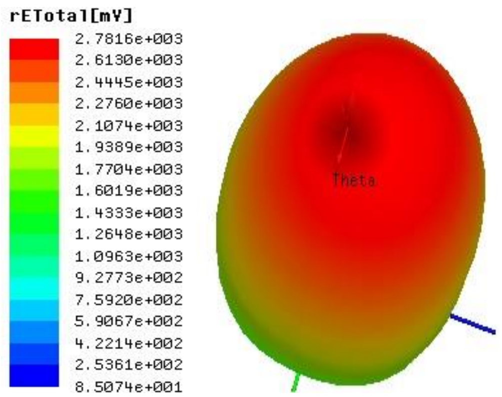
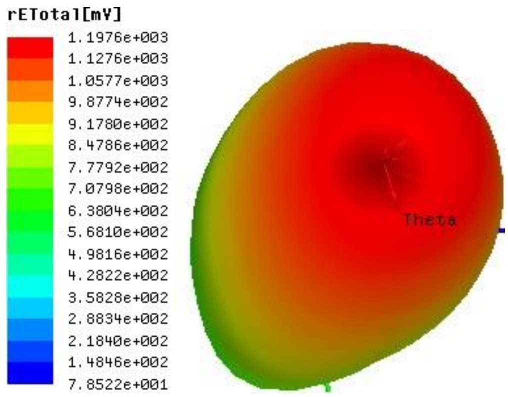


Figure 4: S11Vs Frequency Curve for First Iterative Antenna

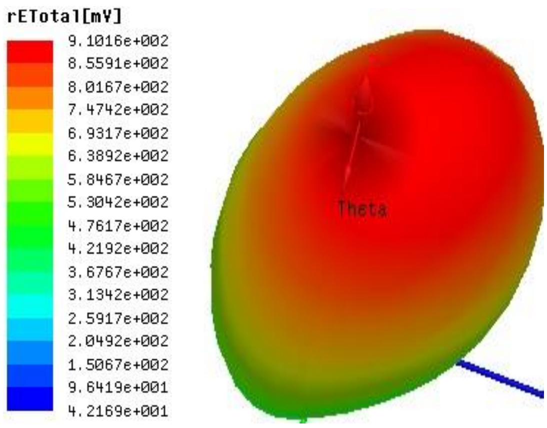
The return loss curve for the second iterative antenna the wide band behavior increases and the return loss is also decreased as compared to the base antenna and the first iterative antenna. The 3 D radiation pattern at 2.4 GHz of the designed fractal antennas is shown in figure 5.



(a)



(b)



(c)

Figure 5: 3-D Radiation Pattern of Design Fractal Antenna

Conclusion

All the three-radiation pattern shows omnidirectional means radiate equally in a single plane. So, it is clear that the above designed antennas show the multiband and wide band property with omnidirectional radiation pattern. These antennas can be used at 2.4 GHz wifi application and IEEE 802.11 a, b, g and n.

Conflict of Interest

There is no conflict of interest between the authors in this manuscript.

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