X – Band Fractal Microstrip Antenna for Wireless Application

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ABSTRACT

Wideband application put a new demand on antennas pertaining to size, gain, efficiency, bandwidth and more. This paper presents the design and analysis of fractal antenna which uses the self similarity property of fractal geometry. This unique property is exploited to develop antenna elements that are wideband and compact possessing highly desirable properties. The presented antenna is circle inscribed octagon shaped. Simulation results show that the antenna can be used in X band frequency range exhibiting wideband properties. Radiation pattern and gain characteristics are also analysed.

Key words

Fractals, Wide Band, Fractal Microstrip Patch Antenna, X band.

1. INTRODUCTION

Modern developments in communication systems require antennas with wider bandwidth and smaller dimensions. Demand for such antennas which are smaller in size, low fabrication complexity and low cost has increased in military as well as commercial applications. For conventional antenna if size is less than a quarter wavelength then radiation bandwidth and efficiency is reduced [3]. This problem is overcome by using fractal geometry in designing antennas.

Fractals have self similar shapes and space filling properties that can be subdivided into parts. This property makes the fractal antenna compact and wideband. The different fractal elements of the antenna make it to have different resonances. The presence of discontinuities in the geometry increases the bandwidth and radiation properties of antenna. It also has long electrical lengths that fit into a compact size [8][5].

In this paper a new fractal geometry which is circle in octagon shaped is designed. Antenna parameters for operating frequency of 10GHz, in X band frequency ranges are analysed and found to exhibit multiple bands. Simulation is done in Ansoft HFSS software and the results are compared.

2. DESIGN APPROACH

Fractal microstrip patch antenna is designed based on iterative method [8]. Dimension of each iteration is different. A number of iterations can be performed but considering fractal antenna's compactness only three iterations are performed. Also, in higher iterations there is no significant change in antenna properties [1].

The interior and exterior radius of the octagon, as shown in figure 1, is given by

$$\boldsymbol{r_e} = \frac{\boldsymbol{a}}{2} * \sqrt{4 + 2\sqrt{2}}$$

$$\boldsymbol{r_i} = \frac{\boldsymbol{a}}{2} * \sqrt{1 + \sqrt{2}}$$

Where,

a – side of the octagon

r_e – External radius

r_i – Internal radius

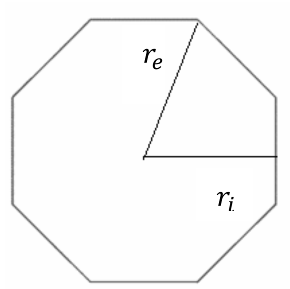


Figure 1: Geometry of Octagonal Sub array

The array factor of the fractal antenna is given by [4],

$$\boldsymbol{AF}_p = \prod_{p=1}^{p} GA(\delta^{p-1}\psi)$$

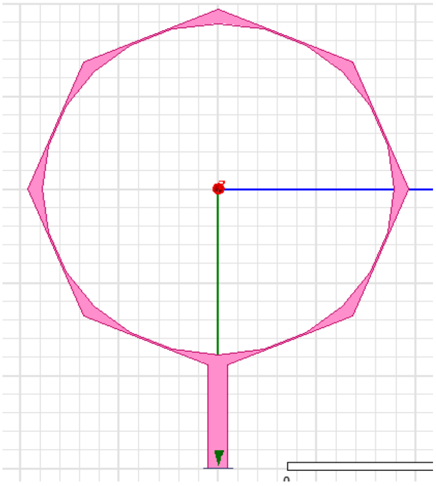
Where,

δ - Scaling factor

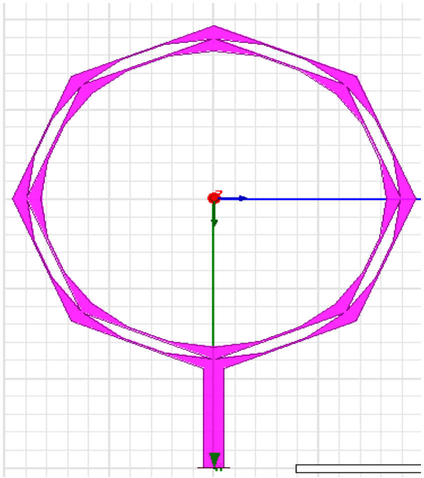
P - Level of iteration

$GA\psi$ – Array Factor Associated with Generating Array

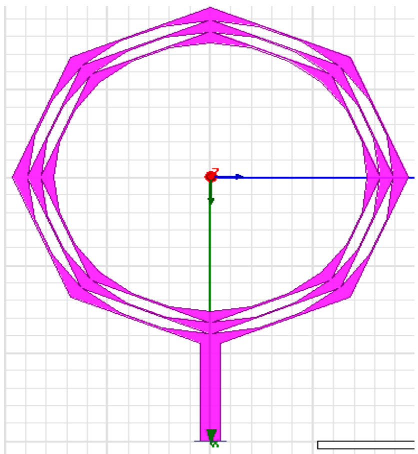
The radius of the circle that is subtracted from the octagon is the interior radius of the octagon. This is repeated till the third iteration is obtained. The side of the first iterative octagon is a=14.7mm and radius of the first inner circle subtracted is r=17.8mm. The three iterative patterns with CPW feed are shown in figure 2.



a. First Iteration



b. Second Iteration



c. Third Iteration

Figure 2: Iterations with CPW Feed

The dimensions of the ground plane is 60x60 mm. The antenna is placed on fr4 substrate with ϵ_r = 4.4 and thickness 0.25mm. The substrate is placed over a ground plane of perfect conductor with thickness 1mm. CPW feed of length 11.2mm and width 2mm is given to the patch. CPW feed is used because it exhibits broad bandwidth matching, coplanar capability low dispersion at higher frequencies and ease of design and fabrication [2]. Feed dimensions are selected to obtain impedance of 50 ohms for proper impedance matching. A wave port is designed at the end of the feed line.

3. SIMULATION RESULTS AND DISCUSSION

Antenna is designed using High Frequency Structured Simulator (HFSS) software. The patch is a perfect – E conductor. The third iteration is found to have improved antenna parameters compared to the first and second. Return loss plots for second and third iterations in the X-band frequency range of 8GHz – 12GHz operating at 10GHz is shown in figure 3. It is observed that the return loss characteristics reduce as the number of iteration increase.

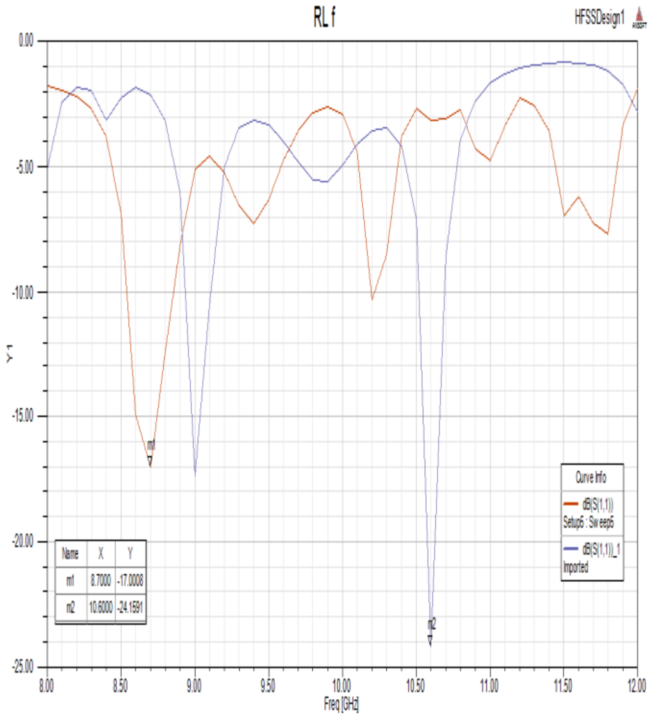


Figure 3: Return Loss Plot of second and third iteration

Gain Vs frequency plot of different iterations shown in figure 4. In 8GHz – 12GHz, a wide bandwidth of 3.2112GHz is obtained in the range of 8.53GHz – 11.7470GHz for the third iteration. It is observed that wideband characteristics have improved, as number of iteration increase, due to the current along its edges.

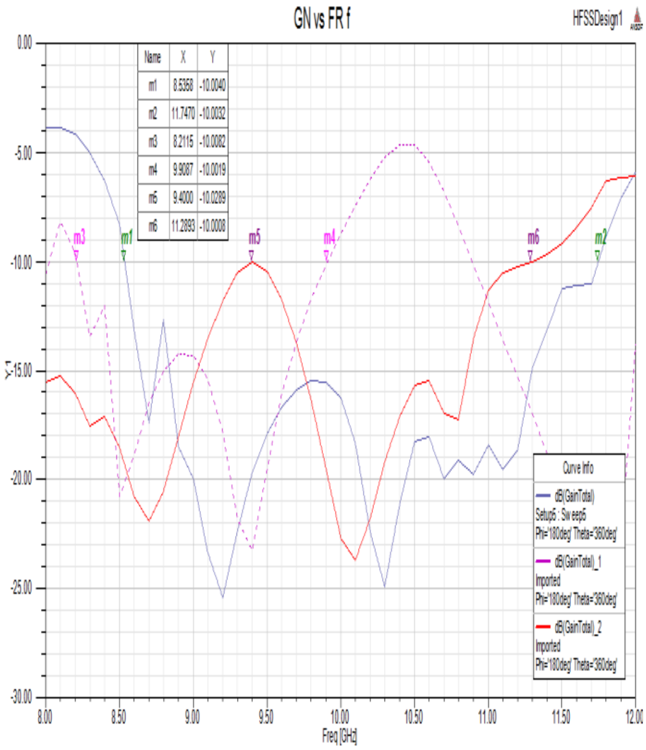


Figure 4: Gain Vs Frequency Plot

Radiation pattern is shown in figure 5. It is observed that the number of side lobes is reduced in the third iteration. 3-D Radiation Pattern of third iteration is shown in figure 6.

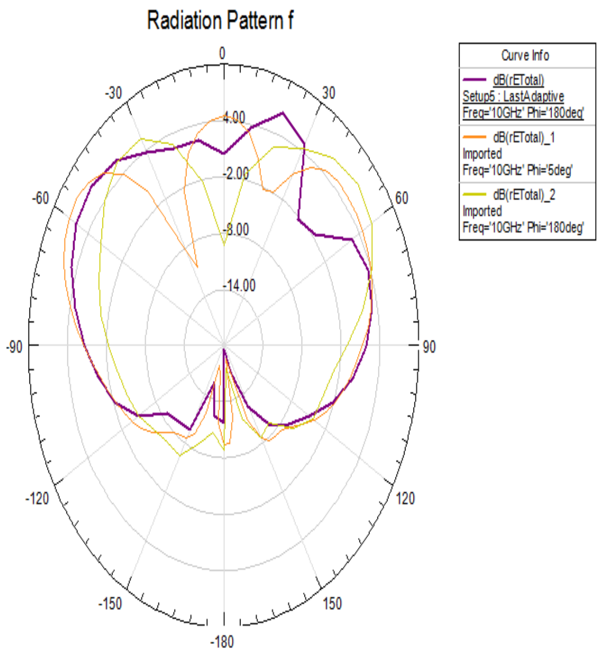


Figure 5: Radiation Pattern

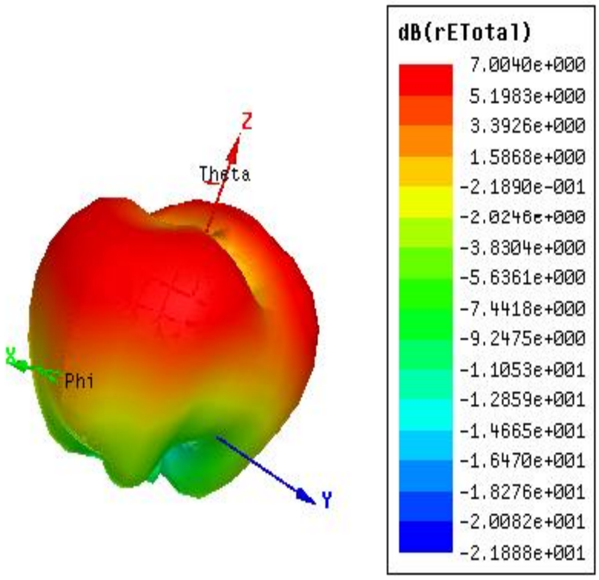


Figure 6: Third Iteration 3-D Radiation Pattern

4. CONCLUSION

The new fractal antenna is designed and simulated using HFSS software. Results in X band frequency range of 8GHz-12GHz has been analysed. It is observed that the third iteration of the fractal antenna exhibits good wideband characteristics, which can be used in wireless application such as, terrestrial broadband, armature radio and satellite communication. This microstrip antenna assures simplicity in design and fabrication.

5. ACKNOLEDGEMENT

We the authors would like to thank the Registrar Dr.K.O.Joseph, Principal Dr.N.Ramaraj and HOD Dr.D.Balasubramanian for their constant encouragement rendered in completion of this project with their constant technical support and invaluable guidance.

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