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Wideband 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 different frequency ranges exhibiting wideband properties. Radiation pattern and gain characteristics are also analysed.

Key words – *Fractals, Wide Band, Fractal Microstrip Patch Antenna.*

I. 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 [1]. 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 operating in wideband frequencies. The different fractal elements of the antenna allow 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 [2][3].

In this paper a new fractal geometry which is circle in octagon shaped is designed. Antenna parameters for different operating frequencies of 20GHz and 10GHz, in different frequency ranges are analysed and found to exhibit multiple bands in a huge bandwidth. Simulation is done in Ansoft HFSS software and the results are compared.

II. DESIGN APPROACH

Fractal microstrip patch antenna is designed based on iterative method [2]. 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 [4]. 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

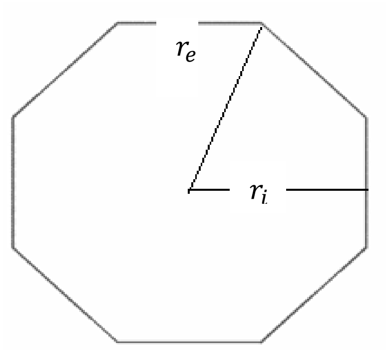

Figure 1: Geometry of Octagonal Sub array

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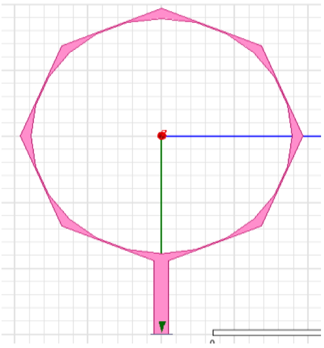
The array factor of the fractal antenna is given by [4],

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

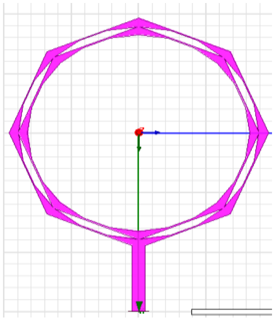
Where,

δ - Scaling factor
P - Level of iteration
$GA\psi$ – Array Factor Associated with Generating Array

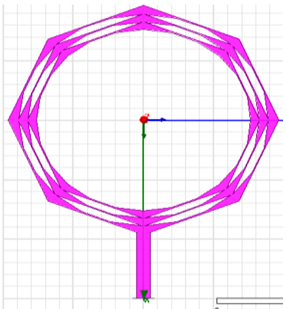
The radius of the circle that is subtracted from the octagon is the interior radius of the octagon. This is repeated till the third iteration is obtained. The side of the first iterative octagon is a=14.7mm and radius of the first inner circle subtracted is r=17.8mm. The three iterative patterns with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



First Iteration



Second Iteration



Third Iteration

Figure 2: Iterations with CPW Feed

The dimension of the ground plane is 60x60 mm. The antenna is placed on FR4 substrate with permittivity ϵ_r = 4.4 and thickness 0.25mm. The substrate is placed over a ground plane of pec 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 [8]. 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.

III. SIMULATION RESULTS AND DISCUSSION

Antenna is designed using High Frequency Structured Simulator (HFSS). The patch is a perfect – E conductor. The third iteration is found to have improved antenna parameters compared to the first and second. Comparison of return loss plots for second and third iterations in the frequency range of 1GHz – 18GHz operating at 10GHz is shown in figure 3 and 10GHz – 40GHz operating at 20GHz is shown in figure 4. It is observed that the return loss of third iteration is less than the second in both frequency ranges.

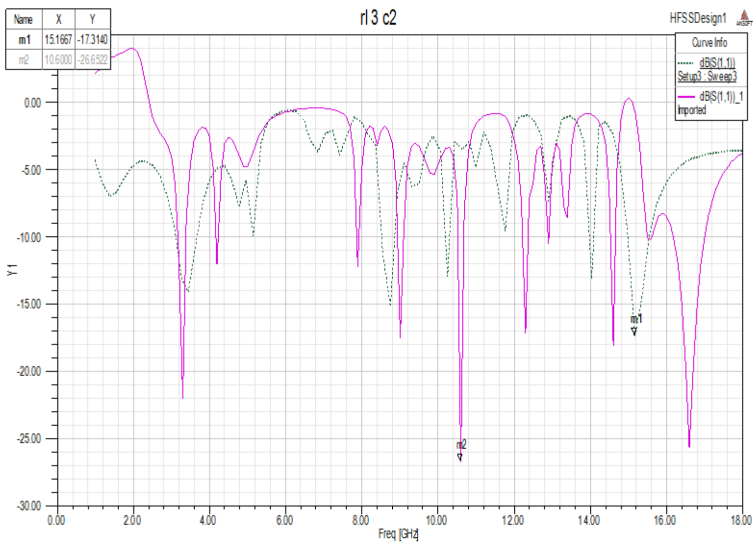


Figure 3: Return Loss Plot (1GHz – 18 GHz)

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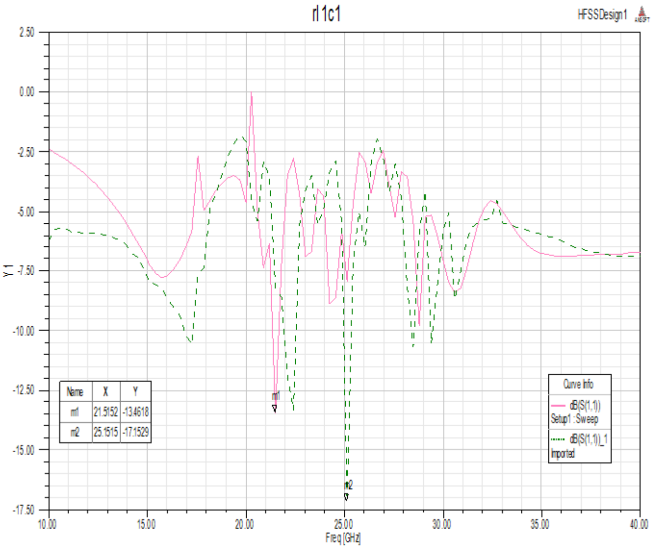


Figure 4: Return Loss Plot (10GHz – 40GHz)

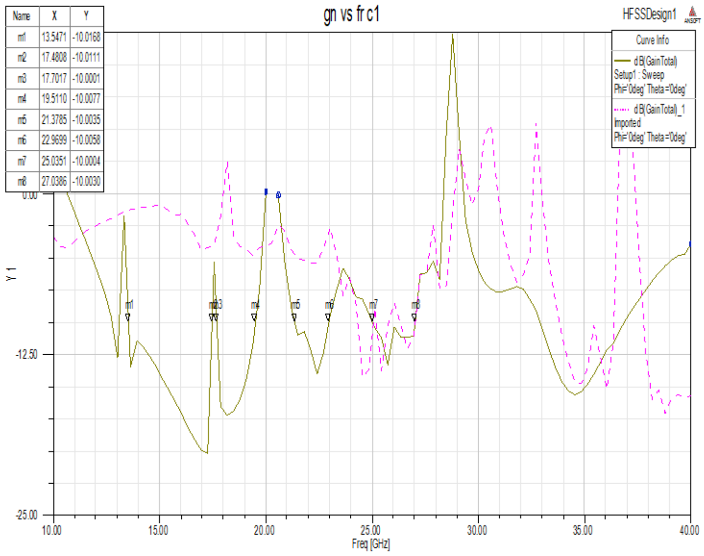


Figure 6: Gain Vs Frequency Plot, 10GHz – 40GHz

Gain Vs frequency plot of the second and third iteration for 1GHz – 18GHz range is shown in figure 5. It is observed that for the third iteration a bandwidth of 5.954GHz corresponding to 198.33% is obtained in the range of 5.62GHz – 11.57GHz. Gain Vs frequency plot for 10GHz – 40GHz is shown in Figure 6. From the figure, the third iteration found to have multiple bands. Some of the significant bands are from 13.54GHz – 17.48GHz, 17.70GHz -19.91GHz, 25.03GHz - 26.03GHz, with bandwidths of 3.94GHz, 2.21GHz, and 1GHz respectively. From the results it is inferred that, this antenna can be used for huge bandwidth exhibiting multiple frequency response characteristics.

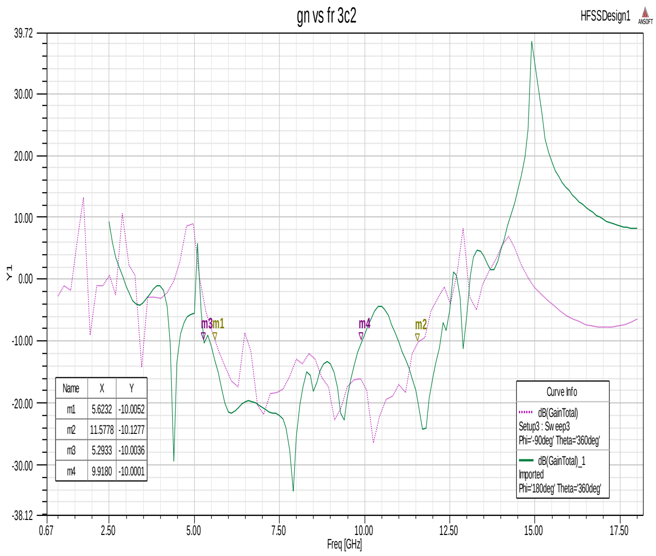
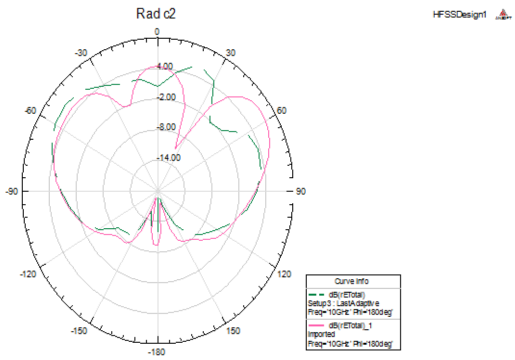
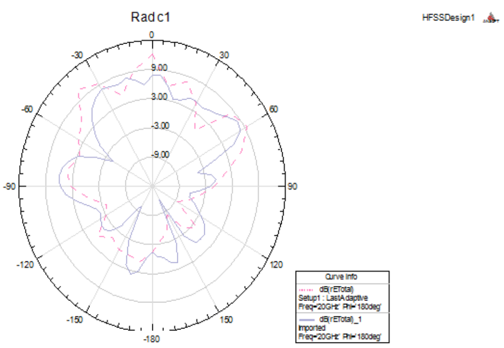


Figure 5: Gain Vs Frequency Plot, 1GHz – 18GHz

An omni-directional radiation pattern is obtained at different frequencies as shown in figure 8. It can be observed that the number of side lobes has significantly reduces as number of iteration increases.



a. 1GHz – 18GHz operating at 10GHz



b. 10GHz – 40GHz operating at 20GHz

Figure 8: Radiation Pattern

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IV. CONCLUSION

The new fractal antenna is designed and simulated using HFSS software. Results for different operating frequencies for different frequency range 1GHz-18GHz and 10GHz – 40GHz has been analysed. Since it exhibit good wideband characteristics, it has found its application in satellite communication, radio communication and in many wireless application. This microstrip antenna assures simplicity in design and fabrication.

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