



## Design of Hexagonal Fractal Multiband Antenna with Parametric Analysis

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### ABSTRACT

With the rapid evolution in wireless communication systems and increasing importance next generation wireless applications, wideband and low profile antennas are in great demand for both commercial and military applications. The need of multiband, larger gain and low profile antennas to support multiple wireless applications led to the design of Fractal Antennas. Fractal antennas due to their self-similar design take less area and are thus low profile. Further they can obtain radiation pattern and input impedance similar to a larger multiband antennas.

This paper presents the design of hexagonal fractal antenna up to third iteration. The proposed antenna is designed on FR4 substrate with dielectric constant of 4.4 and fed with 50 ohms microstrip line. By optimizing the width microstrip feed and its location the antenna can be optimized to operate in multiple bands between 1-5GHz.

**Key words:** About four key words or phrases in alphabetical order, separated by commas.

### 1. INTRODUCTION

Antennas enable wireless communications between two or more stations by directing signals toward the stations. An antenna is defined by Webster's Dictionary as —a usually metallic device (as a rod or wire) for radiating or receiving radio waves. The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as —a means for radiating or receiving radio waves [2].

For wireless communication system, antenna is one of the most critical components. A good design of the antenna can thus improve overall system performance. Microstrip patch antennas are widely implemented in many applications due to their attractive features such as low profile, light weight, conformal shaping, low cost, high efficiency, simplicity of manufacture and easy integration to circuits. However the major disadvantage of the microstrip patch antenna is its inherently narrow impedance bandwidth.

A fractal antenna is an antenna that uses a fractal, self similar design to maximize the length, or increase the perimeter of material that can receive or transmit electromagnetic radiation within a given total surface area or volume. [3].

Fractals create from self-similar elements, iterating in various directions that increasing iterations does not change their total

form; because their small sections are reduced-size copy of the whole. Self-similarity of fractals causes multi-band and broadband properties of antennas [8]. Due to the concept of self-similarity and infinite complexities, the proposed geometry of an antenna is very versatile in term of polarization, radiation pattern, gain and bandwidth [9, 10].

### 2. ANTENNA DESIGN

The hexagonal fractal microstrip antenna for three iterations has shown in figure.1. The hexagonal fractal is constructed by reducing a hexagon generator shape to one third its former size, and grouping six smaller hexagons together. The hexagonal patch is fabricated on FR4 substrate of height 1.6 with relative dielectric constant 4.4 whose loss of tangent 0.002.  $a=24$ ,  $c=8$ ,  $d=2.6$ mm.  $W_s=90$  mm,  $L_s=110$  mm.

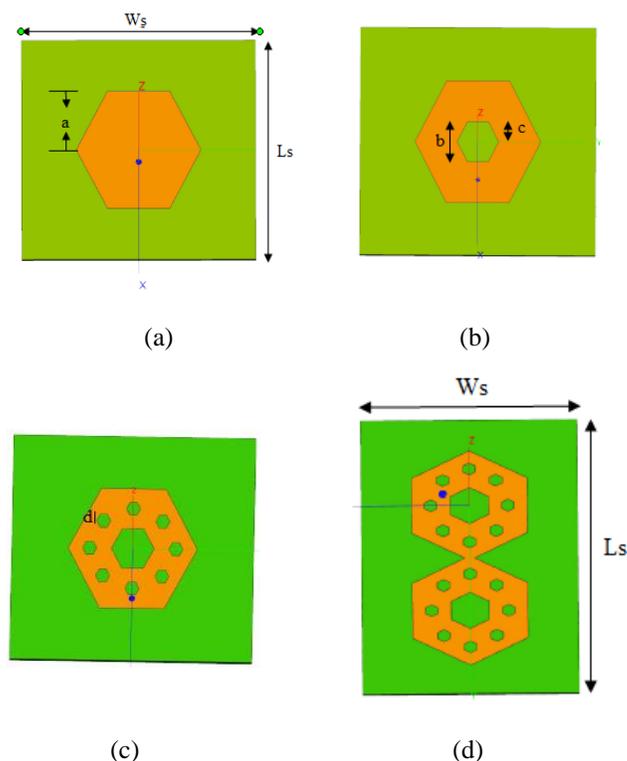


Figure.1: first three iteration of hexagonal fractal antenna.

### 3. SIMULATED RESULT

The first three iteration of the corner-fed hexagonal fractal monopole are measured and have been examined using the method of moment.

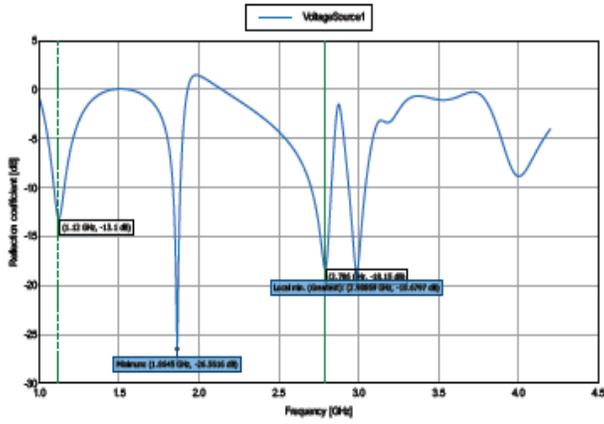


Figure 2: reflection coefficient magnitude [dB]- fractal\_3<sup>rd</sup> iteration array.

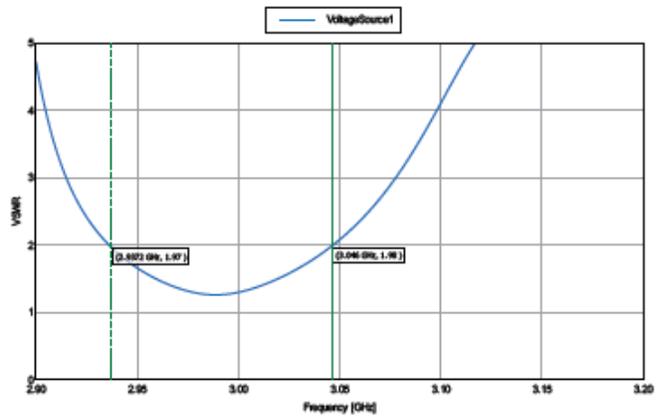


Figure 6: VSWR-Fractal\_3<sup>rd</sup> iteration array.

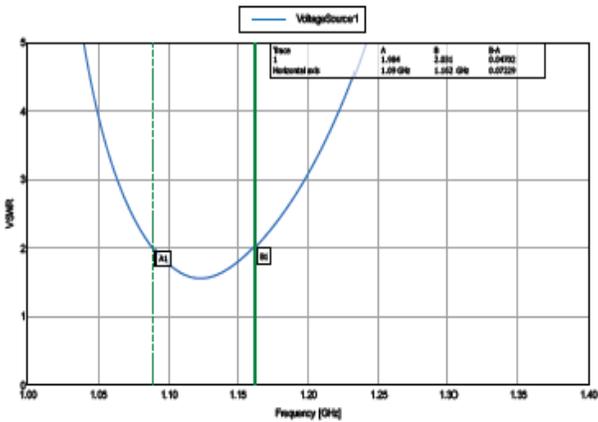


Figure 3: VSWR-Fractal\_3<sup>rd</sup> iteration array.

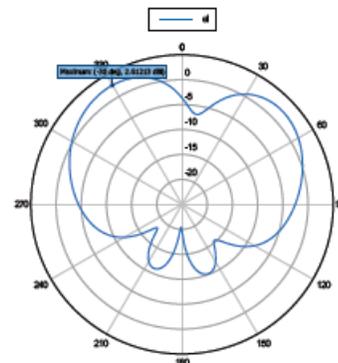


Figure 7: phi gain [dBi] (frequency = 2.81818 GHz; phi = 90 deg) – fractal\_3<sup>rd</sup> iteration array.

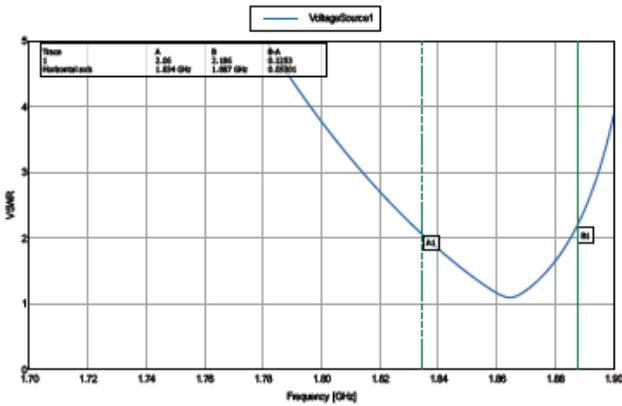


Figure 4: VSWR-Fractal\_3<sup>rd</sup> iteration array.

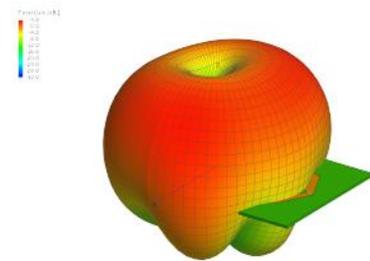


Figure 8: 3D VIEW

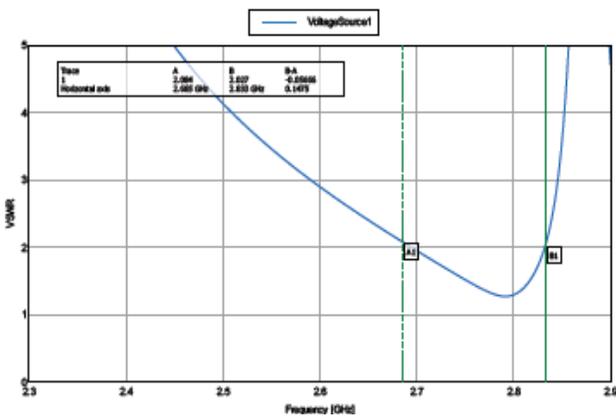


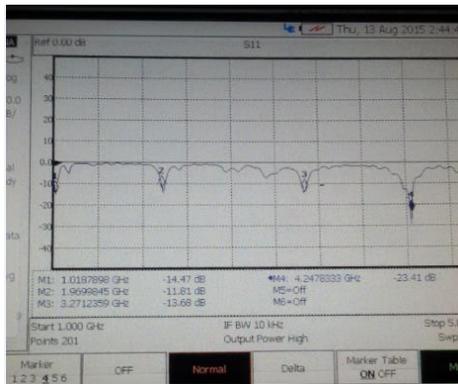
Figure 5: VSWR-Fractal\_3<sup>rd</sup> iteration array

#### 4. FABRICATION AND MEASUREMENT

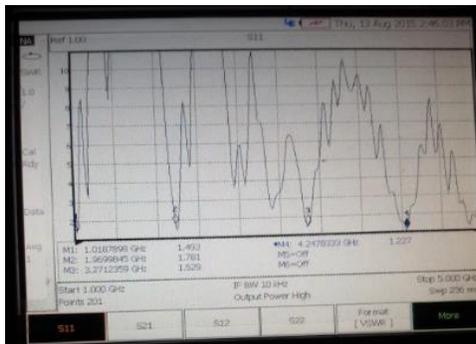
3rd iteration SCFA has been fabricated using FR4 substrate. N-type female (SMA) connector is soldered at the micro strip feed end. Figure.9 shows the front view of the fabricated antenna.



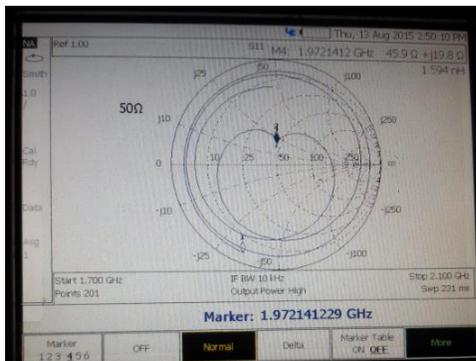
**Figure.9.** photograph of fabricated 3<sup>rd</sup> iteration



(a)Return Loss



(b)VSWR



(c)Impedance

**Figure.10.** Result of fabricated antenna. (a) Return loss (b) VSWR (c) Impedance

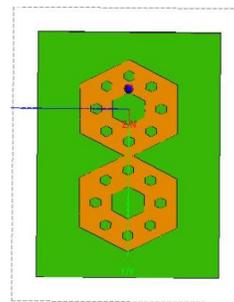
Figure.9. above shows the testing of fabricated 3<sup>rd</sup> iteration hexagonal fractal antenna using a Vector Network Analyzer (VNA). Figure 10 (a) shows the S11 graph for the fabricated antenna and Table shows the comparison between simulation and fabrication results.

A good agreement between experimental and simulated results is observed except some slight variation. This may be due to the tolerance in manufacturing, uncertainty of the thickness and/or the dielectric constant of the substrate and lower quality of SMA connector (VSWR = 1.3), larger  $\tan \delta = 0.02$  of the substrate and soldering effects of an SMA connector.

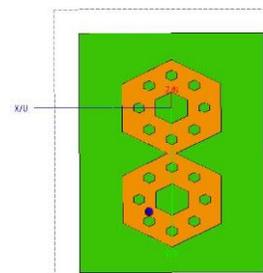
**Table .1** Comparisons of simulated and fabricated results for 3<sup>rd</sup> iteration Hexagonal Fractal Antenna.

Frequency band	simulated	fabricated
Band 1	1.12	1.02
Band 2	1.86	1.96
Band 3	2.78	3.27
Band 4	2.98	4.24

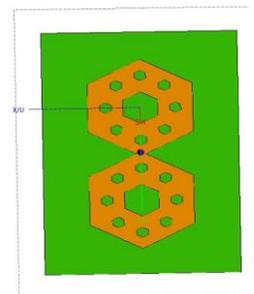
### 5. PARAMETRIC ANALYSIS OF FEED POSITION FOR 3<sup>rd</sup> ITERATION



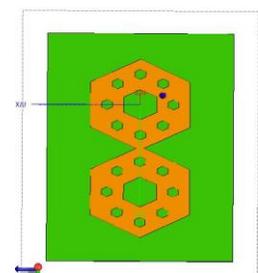
**Figure (a):**feedcenter



**Figure (b):**feedbottom



**Figure (c):** Feedmiddle



**Figure (d):**feedright

**Figure. 11.** Feed position fractal 3<sup>rd</sup> iteration

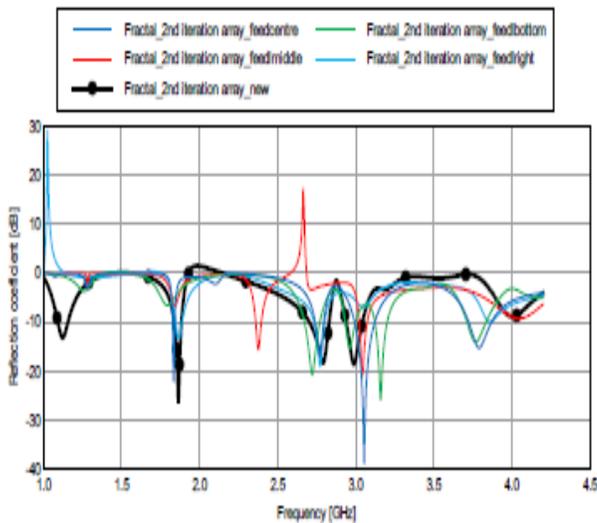


figure.12 .comparison of feed position with fractal 3<sup>rd</sup> iteration

## 5. CONCLUSION

In this paper a micro strip fed hexagonal fractal antenna is designed and implemented up to 3<sup>rd</sup> iteration. Hexagonal fractal with 1/3 iteration factor the size of the patch reduces by 33.9% of the conventional micro strip antenna. As the iterations go on increasing the loading causes multiple resonance and a shift down in frequency. The fabricated 3rd iteration hexagonal fractal antenna results are in good match with the simulation results.

## ACKNOWLEDGEMENT

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