ARPN Journal of Engineering and Applied Sciences

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PERFORMANCE ESTIMATION OF MICROSTRIP ANTENNA WITH SIERPINSKI GASKET INVERTED FRACTALS

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ABSTRACT

In many commercial and defence communication systems, there is a need of compact antennas with high performance, considerable gain and compactness in size. The modern communication systems need such antennas which operates at multiband with wide bandwidth. One of the technique to satisfy that needs is the implementation of fractal geometry on the microstrip antenna radiator. It has been proved that fractal antennas have their own unique characteristics without changing the antenna properties. In the current paper, the performance of the microstrip patch antenna with Sierpinski gasket fractals as inverted triangles has been presented. The base antenna without fractals has been designed at 8.45GHZ operating frequency. As the base antenna offers narrow band width with single resonant frequency, triangular fractal geometry was implemented on the patch upto the second iteration to improve the gain and wide band width at multi bands. The fractal antenna characteristics are analysed at each iteration by using electromagnetic simulator HFSS 13.

Keywords: inverted triangular fractals, sierpinski gasket, HFSS software, multiband, wide bandwidth, iteration, space filling.

INTRODUCTION

In any commercial and military communication systems, the multi band antennas with wide bandwidth are needed for advanced wireless applications. To meet this needs one of the technique implemented is fractal shaped antenna elements. It has been proved that Fractal shaped antenna has some unique property as repeated geometry on the patch radiator to fill the space effectively. Due to this space filling technique, the electrical size of antenna is increased with physical compactness. Due to the increase in the electrical size of the antenna performance is improved. Several geometries are available like Helix, Koch curve and Sierpinski carpet etc. In the current paper, Sierpinski fractal antenna with inverted triangle structure was implemented up to second order iteration. Its performance is observed to be varied from iteration to iteration with inverted triangular fractals.

Antenna geometry

The basic microstrip patch antenna is very compact in nature and its dimensions are taken as 30x34.64x2mm on substrate with line feeding. In the current project, the antenna consists of a Sierpinski gasket radiator with inverted triangle fractals on the top of the substrate material. A substrate material used is Teflon with dielectric constant of 2.1.In Sierpinski gasket geometry, the metallic patch is sub divided into inverted triangles in three iterations as shown in the Figure-1. In the Iteration 1, a single Triangle is obtained by decomposing the rectangular microstrip patch. In the Iteration 2, the larger triangle is divided into 3 inverted equilateral triangles. In Iteration 3, the left over radiator is again filled by 3 inverted triangles of small size. The antenna is sourced by microstrip line feed with 50Ω impedance.

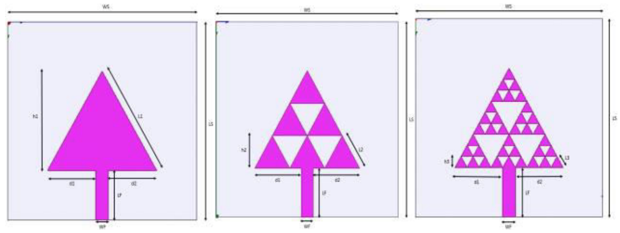

Figure-1. Three iterative stages of Sierpinski Gasket Inverted Triangle Fractal Antenna.

The resonant frequency of the basic rectangular patch microstrip antenna in $TE_{1,\ 0mode}$ is calculated by using the below equations.

$$f_{mn} = \frac{c}{2\epsilon_{reff}}\left[\left(\frac{m}{l}\right)^2 + \left(\frac{n}{w}\right)^2\right] \quad (1)$$

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\sqrt{\frac{1}{\left(1+12\frac{h}{w}\right)}} \quad (2)$$

The dimensions of the inverted triangle fractal antenna in three iterations are as shown in the Table-1.

VOL. 11, NO. 15, AUGUST 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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Table-1.

Parameter	Dimensions of **Iteration 1** (mm)	Dimensions of **Iteration 2** (mm)	Dimensions of **Iteration 3** (mm)
LS/LG	60	60	60
WS/WG	60	60	60
L1,L2,L3	34.64,--,--	34.64,11.54,--	34.64,11.54,3.8
h1,h2,h3	30,--,--	30,10,--	30,10,3.33
d1/d2	15.32	15.32	15.32
WF	4	4	4
LF	15	15	15

RESULTS AND DISCUSSIONS

In the current paper, analysis was carried out on the performance of fractal antenna after each iteration. Various antenna parameters like return loss, resonant frequencies, gain, input impedance have been obtained by using the electromagnetic simulator with Finite Element Method (FEM). The basic rectangular patch antenna was resonated at 8.7 GHz with a gain of 6.5 dB and return loss of -18dB. After implementing the fractal geometry, the antenna was resonated at multiple bands with reasonably high performance. After iteration 1, the antenna is resonated at three frequencies 10.9 GHz, 13.3 GHz, 15.1GHz with gain of 7.72, 8.6, 5.52dB respectively. It offers the bandwidths of 0.45 MHz, 1.15 MHz, 0.93 MHz. The corresponding Return losses are -18.37dB, -32.35dB, -29.04dB with VSWR of 1.35, 1.09, 1.07 respectively. The return loss Vs frequency curve of the three iterations is as shown in fig.2. The 2D Gain, VSWR curves with respect to frequency are as shown in Figure-3 and Figure-4 respectively.

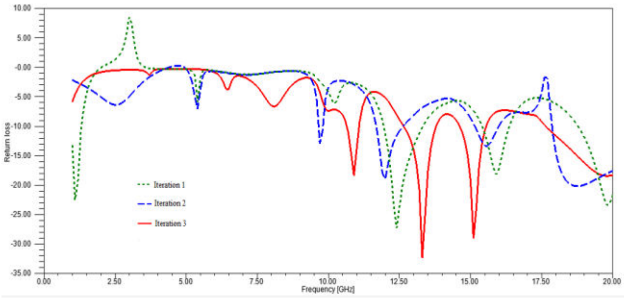

Figure-2. Return loss Vs. Frequency of three iterations.

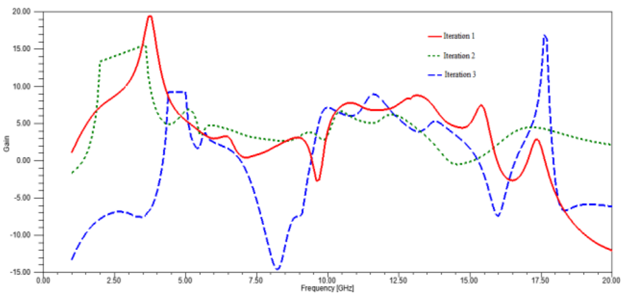

Figure-3. 2D Gain Vs. Frequency of three iterations.

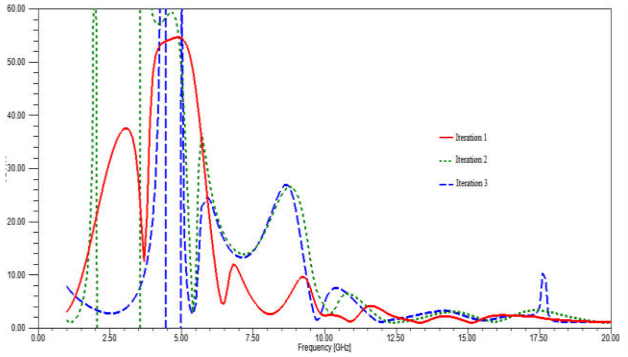

Figure-4. VSWR Vs. Frequency of three iterations.

This fractal antenna input impedances after three iterations are 36.3Ω,43.1Ω,37.7Ω as shown in fig.5.The iteration 2 antenna resonated at two frequencies12.4 GHz, 15.9 GHz with bandwidth 1.38 GHz and 0.96 GHz and gains of 6.10,3.97 dB respectively. After iteration 3, the antenna resonates at two frequencies at 9.7,12 GHz with gains of 5.29dB, 7.71dB. The return losses at the corresponding resonant frequencies are -13.03dB and -19.01dB with VSWRs of 1.65,1.25 respectively. Its corresponding bandwidths are0.15GHz and 0.94GHz. The radiation patterns of three iteration models represents the E and H fields as shown in Figure 6(a) and 6(b).

Compared to the iteration 1 and iteration 3 antenna models, iteration 2 antenna offers good impedance matching with the line feeding but it resonates at only two frequencies. After iteration 1, the antenna resonates at three frequencies with high gains. After all the iterations VSWR values are within the acceptable range of 1 to 2.

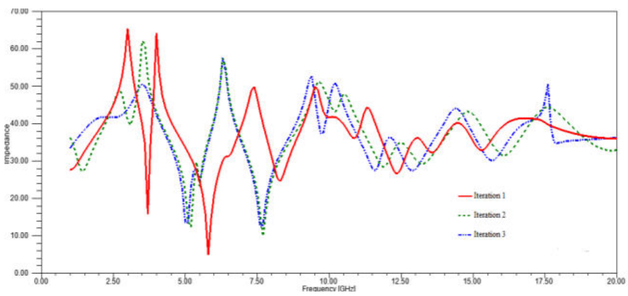

Figure-5. Input impedance of three iterations.

VOL. 11, NO. 15, AUGUST 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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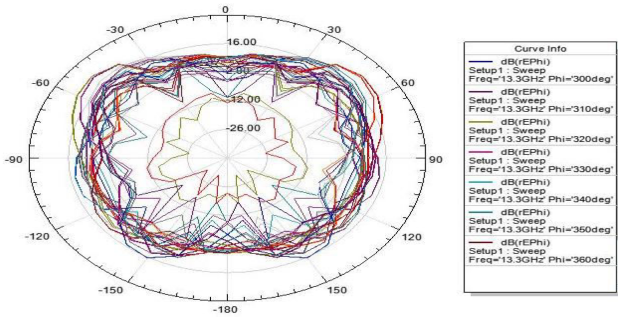

Figure-6(a). Radiation pattern of three iterations.

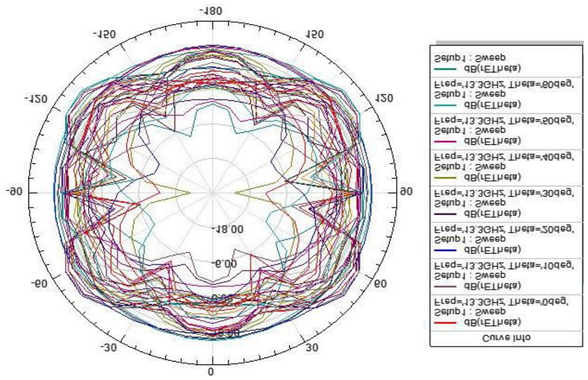

Figure-6(b). Radiation pattern of three iterations.

CONCLUSIONS

The iteration1 antenna design resonates at three frequencies which are in X and Ku band with high return loss and gains. After iteration 2 the antenna resonates at two frequencies in Ku band but it offers high gain at 12.4 GHz with maximum power transfer. Iteration 3 antenna model resonates at two frequencies in X band with high return loss. As the antenna resonant frequencies after each iteration are in the range of either X or Ku band, these models are most suitable for Radar and Satellite applications with high compactness and with good performance and wide bandwidth of around 1000 MHz.

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