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Design of Microstrip Antenna using Sierpinski Carpet Fractal

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Abstract*— *In this paper authors propose a sierpinski carpet fractal rectangular microstrip antenna. By introducing sierpinski carpet fractal in the rectangular microstrip antenna, the size of the antenna is reduced significantly and the radiation characteristics like gain, directivity, antenna efficiency, radiation efficiency and impedance bandwidth are improved.

Index Terms*—*Microstrip antennas, fractal geometry, sierpinski carpet fractal high gain and broad band.

I. INTRODUCTION

In modern wireless communication systems wider bandwidth and low profile antennas are in great demand for both commercial and military applications [1]. This has initiated antenna research in various directions. Recently fractal shaped antenna elements have been introduced for enhancement of different radiation characteristics. Traditionally different antennas operating at different frequencies are needed for numerous applications. This causes a space and orientation problem. In order to overcome this problem, multiband antenna can be used, where a single antenna can operate at many frequency bands [2-3].

One technique to construct a multiband antenna is by applying fractal shape into antenna geometry. It is well known that one of the most important characteristics of fractals is size reduction and space-filling. Therefore, traditional fractals have been used to design compact antennas for multiband or broadband operation [4-6]. With the introduction of fractals in antenna engineering, Hajihshemi and Abiri [7] investigated Ant with fractal shape and reported that with increase in fractal iteration the ratio of surface to volume in Ant increases and thereby enhance the Q-factor which tends to increase in antenna impedance bandwidth.

II. DESCRIPTION OF PROPOSED ANTENNA DESIGN

The geometry of proposed antenna is shown in Figure 1. The study began with the design of a Square patch radiator of length L=71.32 mm on FR4 substrate with a relative dielectric constant (ε_r) of 4.4 and loss tangent of 0.02. An air gap of 1.588 mm is inserted between ground plane and substrate. A strip feed extends from the microstrip line of the same width that ends with the 50 ohm line after certain length that is used as a matching.

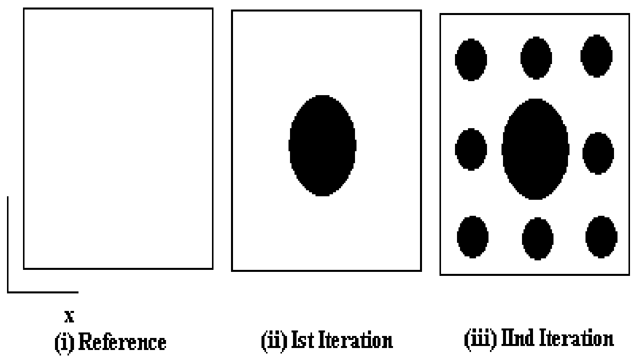

Figure (1): Geometry of Proposed Fractal Antenna

III. SIMULATED RESULTS

The first iteration of the fractal antenna is constructed by etching a circular slot of radius 11.8858 mm at the center of patch. In second iteration eight circular slots of 3.961945 mm radius each that follows the same procedure adopted in first iteration. And in the same fashion the third iteration is also implemented. The simulated results for reference patch, modified patch for first iteration and second iteration are given in Table1. A drastic enhancement in the performance parameters is observed by replacing the infinite ground plane by a finite ground plane of dimensions three times higher than that of patch dimensions. The variations in the S-parameters, Gain, Directivity, Antenna Efficiency and Radiation Efficiency have also been plotted in Figures (2)-(5) respectively.

IV. CONCLUSION

It is clear from the Table 1 that resonant frequencies have been reduced by 1.954% and 1.152% by inserting the second iteration in the reference patch on a finite ground plane. The gains corresponding to first and second frequency have been increased by 22% and 30.9%, antenna efficiencies by 41.79% and 66.94% radiation efficiencies by 41.8% and 65.837%, bandwidths by 96.87% and 278.26% only at the cost of 7.5% and 5.12% reduction in the directivities corresponding to these frequencies.

In this paper, a printed microstrip-fed wideband high gain fractal antenna has been presented. Size reduction and bandwidth enhancement is achieved using sierpinski carpet fractal concept. The second iteration fractal antenna is considered for implementing the antenna shape. The proposed antenna has been simulated, and parametric study has been performed using method of moments based IE3D software.

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Table1: Variation in Parameters by Inserting Fractals

Reference (Air Gap 1.588mm)			IInd Iteration		
Frequency (GHz)	3.0700	3.4700	Frequency (GHz)	2.9700	3.3100
Return Loss (dB)	-26.400	-16.5200	Return Loss (dB)	-11.0800	-11.0000
Directivity(dBi)	6.6000	7.8000	Directivity(dBi)	6.7000	7.40000
Gain(dBi)	5.0000	5.7000	Gain(dBi)	4.6000	4.6000
Efficiency (A) (%)	70.0000	60.0000	Efficiency (A) (%)	61.0000	53.0000
Efficiency (R) (%)	70.0000	60.0000	Efficiency (R) (%)	66.0000	58.0000
Band Width (%)	3.2000	2.3000	Band Width (%)	2.3500	1.2120
Ist Iteration			**IInd Iteration with Finite Ground**		
Frequency (GHz)	3.0600	3.3700	Frequency (GHz)	3.0100	3.4300
Return Loss (dB)	-24.9400	-17.0000	Return Loss (dB)	-24.1300	-17.5600
Directivity(dBi)	6.8000	7.7000	Directivity(dBi)	6.2000	7.4000
Gain(dBi)	5.1000	5.6000	Gain(dBi)	6.2000	7.2400
Efficiency (A) (%)	69.0000	60.0000	Efficiency (A) (%)	100.0000	98.5000
Efficiency (R) (%)	69.0000	61.0000	Efficiency (R) (%)	100.0000	100.0000
Band Width (%)	3.2600	3.5900	Band Width (%)	6.3000	8.7000

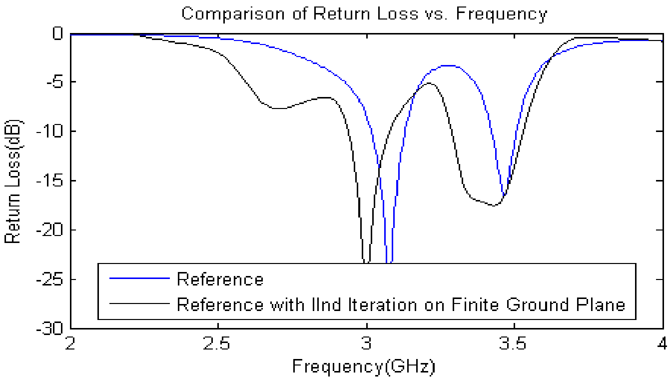

Figure (2): Variations in Return Loss vs. requency.

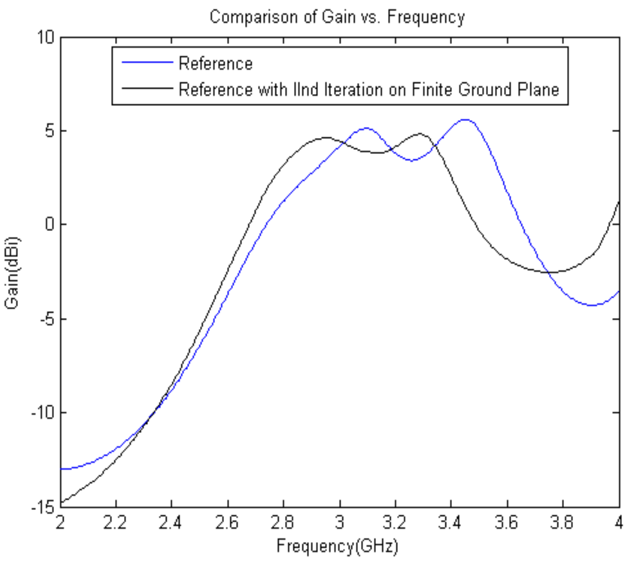

Figure (3): Variations in Gain vs. Frequency for Reference

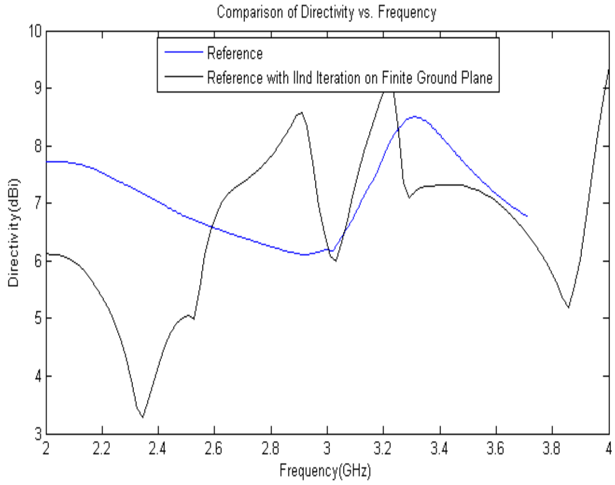

Figure (4): Variations in Directivity vs. Frequency

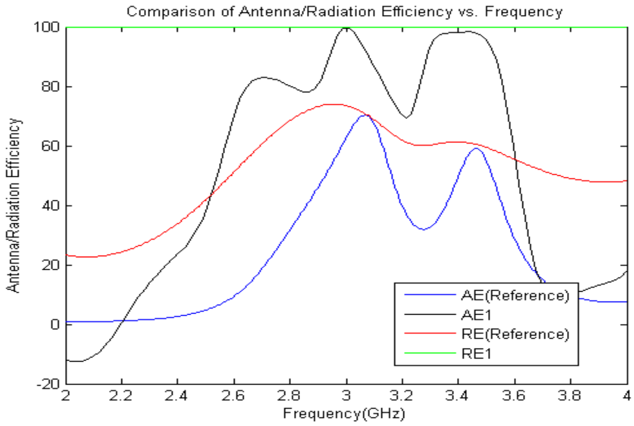

Figure (5): Variations in Antenna/Radiation Efficiency vs. Frequency

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