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Development of a Self-Affine Fractal Multiband Antenna for Wireless Applications

Jagadeesha S.[1], Vani R. M.[2] & P. V. Hunagund[3]

[1]S.D.M Institute of Engineering & Technology, Ujire, Karnataka, India.

[2]Dept. of PG Studies and Research in Applied Electronics, Gulbarga University, India.

[3]Dept. of PG Studies and Research in Applied Electronics, Gulbarga University, India.

E-mail: Jagadeesh.sd69@gmail.com, vanirm12@rediffmail.com, prbhakar_hunagund@yahoomail.com

Abstract: Fractal antennas are characterized by space filling and self-similarity properties which results in considerable size reduction and multiband operation as compared to conventional microstrip antenna. The design of a compact multiband fractal antenna with self-affine property has been presented in this letter. The antenna has been designed on a substrate of dielectric constant $€_r = 4.4$ and thickness 1.6mm. The proposed antenna is characterized by a compact overall dimension. It is probefed fractal patch of iteration two. It is observed that the antenna is radiating at multiple resonant frequencies. The resonant frequency is shifted from 2.32 Gz to 1.75 & 1.26 GHz after I & II iteration respectively. Thus considerable size reduction of 48% & a total bandwidth of 8.6% are achieved. Simulation is carried out using IE3D software and it is found that simulated results are in good agreement with the experimental results.

Keywords: Fractal Antenna, multi frequency, Size reduction, wireless application.

1. INTRODUCTION

Miniaturization of Antennas is one of the trends in modern communication systems [1]. One of the techniques used to decrease the antenna dimensions is the application of fractal geometry [2]. Fractal antennas are characterized by their special geometric structures which allow a reduction of antennas dimensions [3]. Fractal geometry involves a recursive generating methodology that results in contours with infinitely intricate fine structures [4]. The applications of fractal geometry to conventional antenna structures optimize the shape of antennas in order to increase their electrical length, which thus reduces their overall size [5]. Fractal antennas have two main features in common, self-similar and self-affine properties. Self-similarity property is the one that consists of the scaled down copies of itself, that is a contraction which reduces an image by same factors horizontally and vertically. A self-affine set on other hand is a contraction which reduces an image by different factors horizontally and vertically. Thus it can provide additional flexibility in the antenna design. Since by selecting scale factors appropriately resonances can be spaced by different factors [6]. Fractal shape antennas present various advantages which include wide band width and multiband operation. This letter presents a novel design of a fractal antenna with self-affine property and evaluates its suitability for multiband usage.

2. Design Consideration

The antenna is designed on a dielectric substrate having a relative dielectric constant $€_r = 4.4$ and thickness 1.6mm. The iteration factor which represents the construction law of fractal geometry generation is chosen to be one fourth and iteration number is two. The Figure 1c shows the geometry of proposed fractal antenna. The shape of zeroth iteration is a conventional rectangle of dimension 40mm*30mm is mounted on substrate having a ground plane of dimension 50mm*40mm.The multiband antenna with fractal geometry is created by the initial model. A 50 ohm SMA connectors is used to feed the antenna by using probe feed technique. The suitable feed location is obtained at (-4,-8) through optimization process. The input impedance of the antenna was calculated using the IE3D software package, which utilizes the moment method, is applied to efficiently analyzed the characteristic of proposed antenna such as return loss, radiation pattern. Antennas are optimized resulting in the following parameters. h = 1.6mm, L = 30mm, W = 40mm, Lg = 40mm, Wg = 50mm, La = 10mm, Wa = 7.5mm, Lb = 2.8mm, Wb = 4mm. The geometry of reference and its I first and second iterative antenna with scaling of four are shown in Figure 1(a), 1(b) & 1(c)

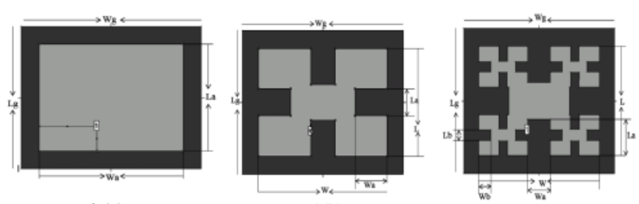
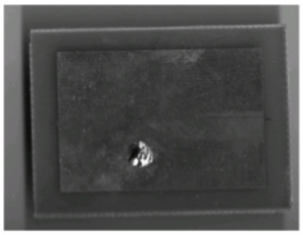
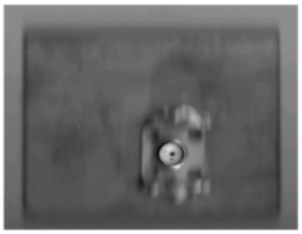


Figure: 1(a) Geometry of Fractal Reference Antenna,1(b) First Iteration Fractal Antenna,1 (c) Second Iteration Fractal Antenna

respectively. All of these antennas are fabricated on 1.6mm-thick substrate with relative permittivity 4.4 is matched by 50ohm SMA connector fed by probe feeding technique. Fabricated photographic view also shown in Figure 2. Figure 2(a) & (b) shows photographic Top and Bottom view of reference antenna structure. Figure 2(c) & (d) shows its First and second iteration with scaling of four.

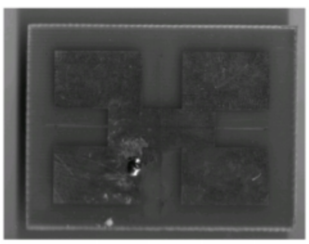


(a)

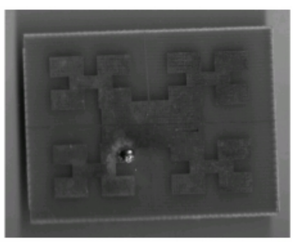


(b)

Figure 2: (a) & (b) Shows Photographic Top and Bottom View of Reference Antenna Structure



(c)

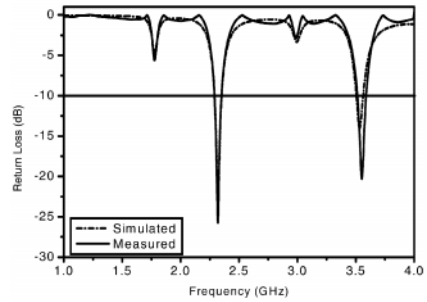


(d)

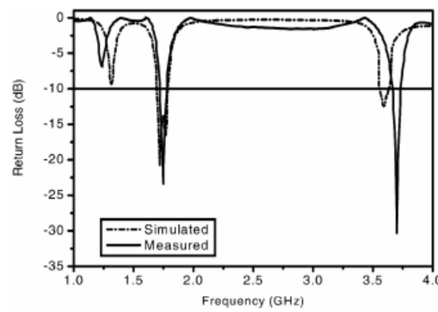
Figure 2: (c) & (d) Shows Its First and Second Iteration with Scaling of Four

3. RESULTS AND DISCUSSION

The first two iteration of probe fed fractal antenna were examined using IE3D simulation tool. The return loss and radiation patterns of the fractal antennas are measured and shown in Figure 3 and 4 respectively. The resonant frequencies of the Zeroth iteration patch resonating at 2.3 GHz, 3.5 GHz respectively. In case of the first iteration patch, the resonant frequencies resonating at 1.75 GHz, 3.6GHz respectively. The resonant frequencies of second iteration patch resonating at 1.26 GHz, 1.51GHz, and 3.6 GHz respectively. After the second iteration, the resonant frequency shift is in significant as summarized in Table 1. Result of different antenna with its with various resonant frequencies whose characteristic features like Return loss and its bandwidth are summarized. Experimental results are close to the simulated results using IE3D Software. These experimental results demonstrate that as iteration increases, the resonant frequency gets lowered. We achieved good size reduction of about 48% as compared to the conventional microstrip antenna. Figure 4 shows the Radiation pattern of conventional antenna operating at 2.3GHz and Radiation pattern of optimized second iterative antenna operating at 1.2 Ghz. From that we can conclude that Broadside radiation pattern are achieved.



(a)



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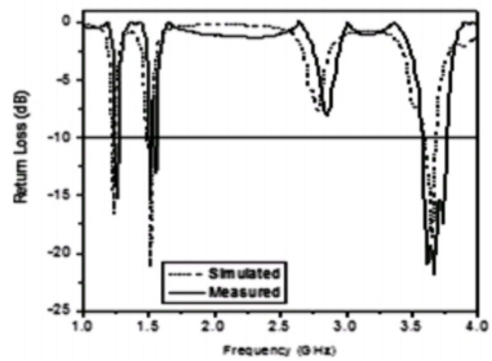
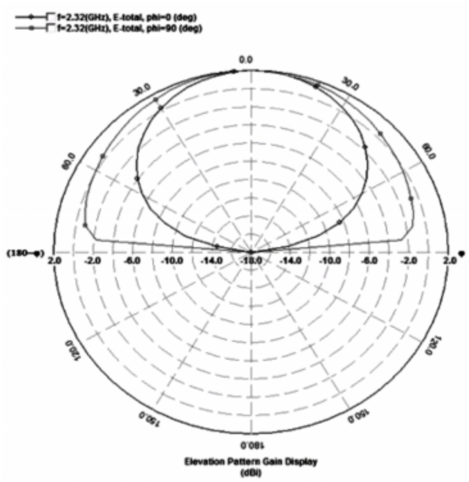
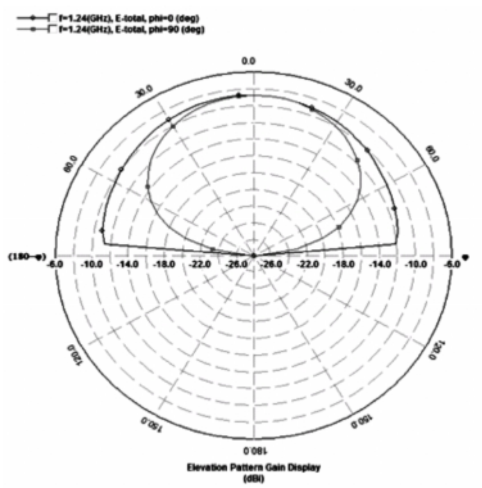


(c)

Figure 3: Return Loss Characteristics of (a) Conventional Antenna, (b) Antenna with First Iteration, (c) Antenna with Second Iteration



(a)



(b)

Figure 4: Simulated Radiation Pattern at (a) 2.3 GHz for Conventional Antenna (b) 1.2GHz for Second Iteration

Table 1
Resonance Frequency Return Loss & Its Bandwidth Results of Reference, Antenna1 and Antenna 2

Prototype Antenna	*Resonant frequency Fr(GHz)*		*Return loss db*		*Bandwidth GHz*		*Band width % age*	
	Sim	*Pract*	*Sim*	*Pract*	*Sim*	*Pract*	*Sim*	*Pract*
Reference	2.32	2.32	-20	-27.9	2.58	2.56	4.04	4.6
Antenna	3.53	3.55	-14	-20	1.49	2.084		
Antenna 1	1.72	1.75	-20	-23	4.65	3.48	6.59	5.1
	3.59	3.7	-12	-30	1.94	1.62		
Antenna 2	1.24	1.26	-17	-15	1.6	2.36	7.4	8.66
	1.51	1.51	-21	-15	3.3	1.3		
	3.6	3.6	-18	-21	2.5	5.0		

4. CONCLUSION

This paper presents a new fractal patch antenna design that can simultaneously support the operation of dual and triple band due to first and second iteration respectively. From the experimental results we can conclude that reference antenna whose resonating frequency operating at 2.3GHz there is a shift in operating frequency to 1.75 &1.26 due to First and Second iteration with scaling factor Four. Thus we can achieved size reduction of 48% with Bandwidth of 8.6% with broadside radiation pattern is achieved. Thus practical results are in good agreement with simulated results.

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