A CPW-Fed Self-affine Fractal Antenna

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In this paper, a new CPW-fed self-affine fractal antenna, which has a novel configuration, is proposed and investigated for low profile and multi-band performance in mobile communication systems. The vastly different structure can be created from a simple rectangular patch while the number of iteration increases. The proposed antenna provides the radiation pattern similar to that of the simple monopole antenna oriented in the y-direction. In addition, the effect of the iteration coefficient, k on the fundamental resonant frequency is studied along with the procedure of antenna design and experimental results.

Introduction

Recently, a variety of fractal designs for multi-band antenna have attracted much attention[1-2]. The total volume of multi-resonant structure can be considerably reduced by optimizing the shape of fractal geometries in designing multi-band antennas[3]. Many studies on the complex fractal structure have been carried out rapidly after the concept of fractal geometry, which provides isotropic self-similarities in large or small scales focused on antenna design and appears to be self-affine properties in signal processing and material surfaces[4-5,8], has been introduced by Mandelbrot[6]. In this paper, we present the behavior of CPW(coplanar waveguide)-fed antenna with self-affine fractal which has anisotropic symmetric scaling factor. Thanks to the advantages of uniplanar feature, low dispersion characteristic and low radiation loss, and simple design, CPW-fed antennas, which are well-known as a candidate for larger input impedance bandwidth, have been widely used in integrating MMICs(monolithic microwave integrated circuits) and packaging active components with low loss transmission line[7].

Antenna design

In fractal geometries, the isotropic self-similar scaling scheme is commonly used to include the self-structure inside a large scale in any direction. Whereas the self-affine objects, which are well defined in [8], proposed in this paper have the different scaling factors in each direction. Consider the radiating geometry having a self-affine characteristic as shown in Figure 1. The generator of each stage from K0 to K3 can be created by the following simple rules:

(1) Diminish the entire size of the previous stage by one-fifths.
(2) Add it twice in horizontal direction and four times in vertical direction.

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It is apparent from Figure 1 (a) to (d) that the shape of the present stage must be similar to that of the previous one by an anisotropic transformation of one-thirds in horizontal direction and one-fifths in vertical direction indicating self-affine fractal structure. Figure 2 shows the self-affine fractal antenna integrated with CPW-fed line. The patch with the dimension $a \times b$ [mm] is symmetrically placed over CPW-fed line with a vertical width, y = 33 [mm] of the ground plane. The simulated results of the antenna are obtained by using a commercially available software, CST MW Studio[9] based on FDTD algorithm. The measurement has been carried out by employing RT/Duroid 5880 substrate with a thickness, 0.787 [mm] and a dielectric constant, 2.2. The optimized value of the CPW-line for 50Ω input matching is a strip width, w = 3 [mm] and a gap width, g = 0.32 [mm].

Simulation and Experimental Results

The simulated and measured results of return loss corresponding to the different stages are plotted in Figure 3. It is observed that the fundamental resonant frequency of K1 stage is about 1 GHz similar to that of K0 stage. As the number of iterations increases, the multi-resonant frequencies of K2 and K3 stages are 1 GHz, 3GHz, 4 GHz and 7 GHz including the fundamental resonant frequency of K1 stage. Figure 4 displays the comparison of return loss versus fundamental resonant frequency corresponding to the each iteration stage. From the results of Figure 4, it is implied that the fundamental resonant frequencies of each stage from K0 to K3 are nearly fixed with a small variations, whereas the overall area of final antenna decreases. Compare to the general fractal antenna such as Koch fractal structures which provide the fundamental resonant frequency inversely proportional to the occupying area of the patch[10], this proposed configuration shows a different performance in terms of fundamental resonant frequency versus occupying area. Table 1 shows the comparison of fundamental frequency with 3 stage iterations. The simulated radiation patterns in K3 fractal at f = 2.18 GHz are shown in Figure 5. Note that the azimuthal(xz-plane) and elevation(yz-plane) patterns are similar to those of the simple monopole antenna due to the anisotropic scaling in horizontal and vertical length determining the shape of the fractal geometries.

Conclusion

The CPW-fed self-affine fractal antenna is introduced. It is seen that the proposed antenna has the reduced size and multi-band characteristics as expected. From the simulation and measured results, it is obtained that the fundamental resonant frequency of self-affine fractal antenna using anisotropic scaling symmetry moves to the lower as the iteration number increases. In addition, it was demonstrated that the radiation patterns of the proposed fractal antenna are nearly same as those of simple monopole antenna even though the overall area of the radiating elements decreases.

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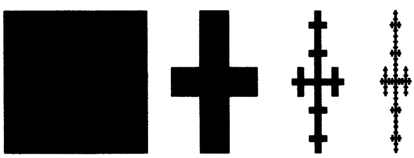
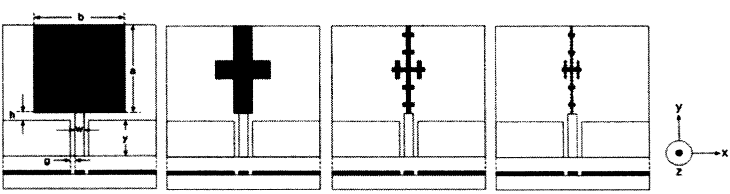


(a) K0 (b) K1 (c) K2 (d) K3

Figure 1. 3 stages of self-affine fractal structure



(a) K0 (b) K1 (c) K2 (d) K3

Figure 2. The geometry of the CPW-fed self-affine fractal antenna
(a = b = 60 [mm], h = 5 [mm])

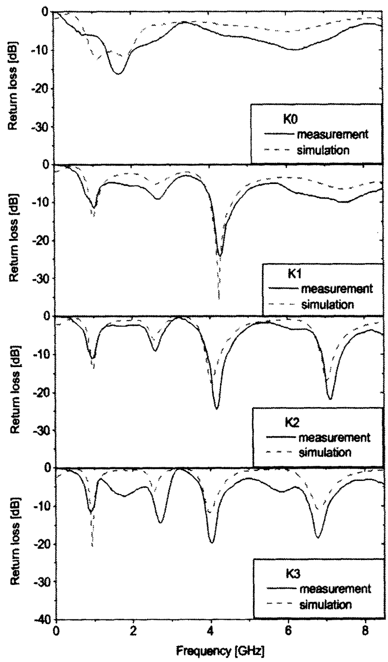


Figure 3. Results of return loss (S11) of proposed antenna from K0 to K3

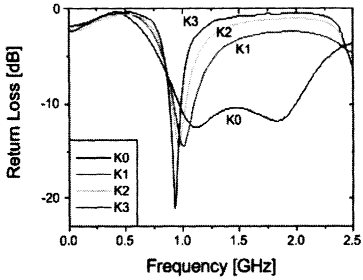
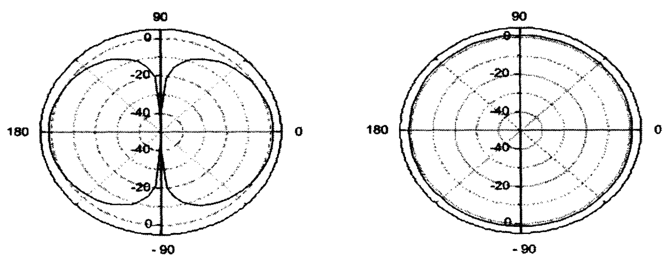


Figure 4. The comparison of return loss versus fundamental resonant frequency corresponding to the iteration numbers

Table 1. The fundamental resonant frequency with 3 stages

	K0	K1	K2	K3
Fundamental frequency (GHz)	1.11	1	0.96	0.93



(a) E-plane(yz-plane) (b) H-plane(xz-plane)

Figure 5. The simulated patterns of K3 fractal antenna at f = 0.93 GHz