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A NEW MULTIBAND PATCH MICROSTRIP PLUSSES FRACTAL ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT

A new compact plusses fractal patch microstrip antenna is investigated to be an efficient scheme of miniaturization based on the simulation results, the proposed antenna has shown to possess an excellent size reduction possibility with good radiation performance for wireless applications. The new designed antenna has an operating frequency of 2.471 GHz, 7.032 GHz, 8.651GHz and 11.86 GHz, with acceptable bandwidth and S_{11}< -10 dB (VSWR<2). The radiation characteristics, VSWR, and S_{11} of the proposed antenna are described and simulated using microwave office MWO 2007 v7.5.

Keywords: microstrip antenna, fractal antenna, multiband antenna, plusses geometry.

1. INTRODUCTION

In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, and low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used [1]. These antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern, and impedance.

There has been an ever growing demand, in both the military as well as the commercial sectors, for antenna design that possesses the following highly desirable attributes:

i) Compact size
ii) Low profile
iii) Conformal
iv) Multiband or broadband

There are a variety of approaches that have been developed over the years, which can be utilized to achieve one or more of these design objectives. The use of fractal geometry is a solution to the design of multiband antennas. The term fractal, which means broken or irregular fragments, was originally coined by Mandelbrot [2] to describe a family of complex shapes that possess an inherent self similarity in their geometrical structure. The original inspiration for the development of fractal geometry came largely from in depth study of the patterns of nature. For instance, fractals have been successfully used to model such complex natural objects as galaxies; cloud boundaries, mountain ranges, coastlines, snowflakes, trees. Leaves, fern, and much more a wide variety of applications for fractals continue to be found in many branches of science and engineering. This geometry, which has been used to model complex objects found in nature such as clouds and coastlines, has space filling properties that can be utilized to miniaturize antennas [3]. One such area is fractal electromagnetic theory for the purpose of investigating a new class of radiation, propagation, and scattering problems. One of the most promising areas of fractal electrodynamics [4-6] research is in its application to antenna theory and design. Modern telecommunication systems require antennas with wider bandwidths and Smaller Dimensions than conventionally possible. This has initiated antenna research in various directions, one of which is by using fractal shaped antenna elements. In recent years several fractal geometries have been introduced for antenna applications with varying degrees of success in improving antenna characteristics. Some of these geometries have been particularly useful in reducing the size of the antenna, while other designs aim at incorporating multi-band characteristics. These are low profile antennas with moderate gain and can be made operative at multiple frequency bands and hence are multi-functional.

In this paper, a multiband antenna is presented as a candidate for use in applications such as wireless local area network (WLAN system of IEEE 802.11b standard-2.4GHz.), industrial scientific medical (ISM-2.4GHz.), and Bluetooth frequency of 2.45GHz

2. GENERATION OF THE PLUSSES FRACTAL ANTENNA

Fractals are basically geometric figures created from a very simple pattern that becomes more complex as we repeatedly apply a certain rule. In many cases, the rule changes the original figure by adding or removing portions of the figure. This process is repeated an infinite number of times. One of the simplest fractals to visualize and work with mathematically is the Plusses fractal. Start with a + sign and add plus signs that are half the size to each of the four line ends. The Figure-1 shows how the Plusses fractal

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grows after 3 iterations. Notice how the + sign grows into the shape of a diamond [7].

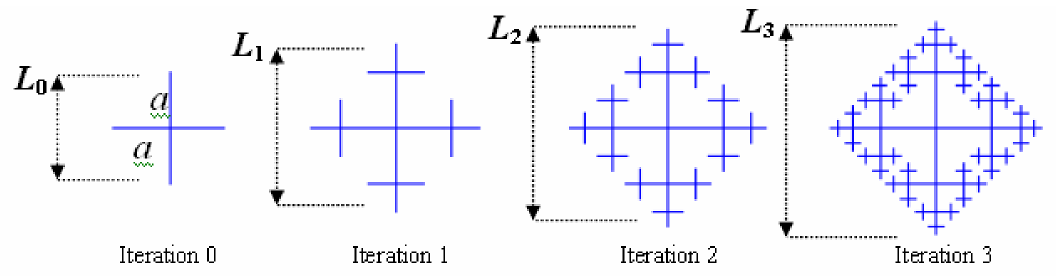


Figure-1. First three iterations of the construction of the plusses fractal geometry.

The side length of the zero iteration plusses fractal antenna, L_0 can be described as:

$$L_0 = 2a \tag{1}$$

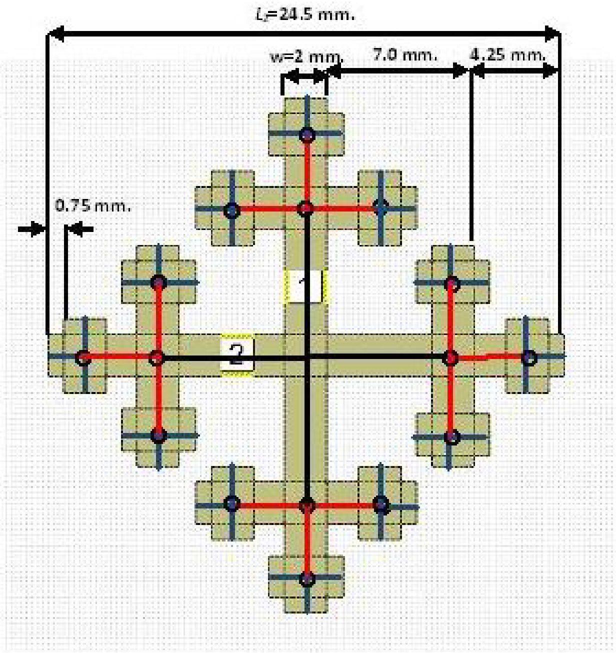
Where a is length of each arm in the plusses fractal geometry.

For the nth iteration, it has been found that, the side length of the plusses fractal antenna L_n is

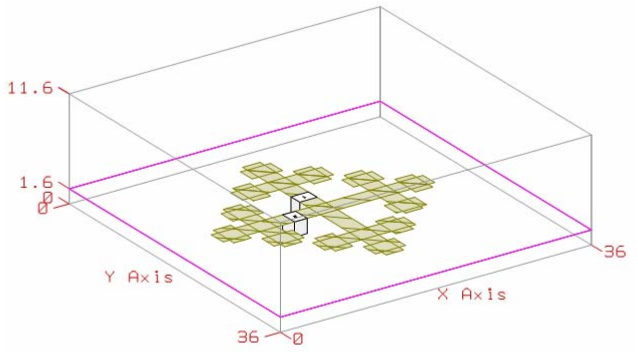
$$L_n = L_{(n-1)} + \frac{a}{2^{(n-1)}} \quad \text{for } n > 0 \tag{2}$$

3. DESIGN AND SIMULATION OF THE PROPOSED ANTENNA

A second iteration plusses fractal patch antenna with two pairs of orthogonal feeds at x = 1.5 mm and y = 1.5 mm is shown in Figure-2(b), and using substrate FR4 with a relative dielectric constant, $\varepsilon_r = 4.4$, a substrate height, h = 1.6 mm, loss tangent, tan δ = 0.019, and the dimensions of the dielectric layer are 36 x 36 mm^2. The width of the antenna trace (w) has been chosen to be 2mm. In this work, microwave office (MOW 2007 v7.5) is used to perform a detailed study of voltage standing wave ratio (VSWR), return loss (S_{11}), and radiation field pattern of the proposed Plusses fractal antenna.



(a) Two dimensional view of proposed antenna



(b) Three dimensional view of proposed antenna.

Figure-2. The proposed antenna.

At first, a plusses antenna has been modeled with a side length; L of 28 mm. Depicted in Figure-3, the return loss, S_{11} response of this model shows an obvious multiband behavior with first resonance frequency at 2.152 GHz.

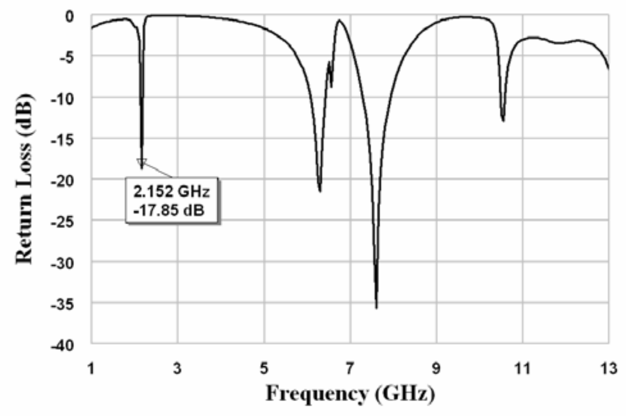


Figure-3. Simulated return loss of the proposed antenna with side length, *L* of 28 mm.

Using the concept of dimension scaling [8], this initial structure is then frequency scaled to the desired frequency, 2.45 GHz. The resulting plusses antenna has been found to have a side length of 24.5 mm.

Figure-2 shows the two and three dimension of the second iteration plusses fractal patch microstrip antenna with side length, *L* of 24.5 mm.

The corresponding return loss and VSWR responses of this antenna are depicted in Figures 4 and 5, respectively. The first resonance takes place at a frequency of approximately 2.45 GHz, where the multi-resonant behavior is very clear. There are four different resonant frequencies, for $S_{11} \leq -10$dB (VSWR ≤ 2) with reasonable bandwidths around each. These frequencies are 2.471, 7.032, 8.651 and 11.86 GHz, respectively, throughout a swept frequency range from 1 to 13 GHz.

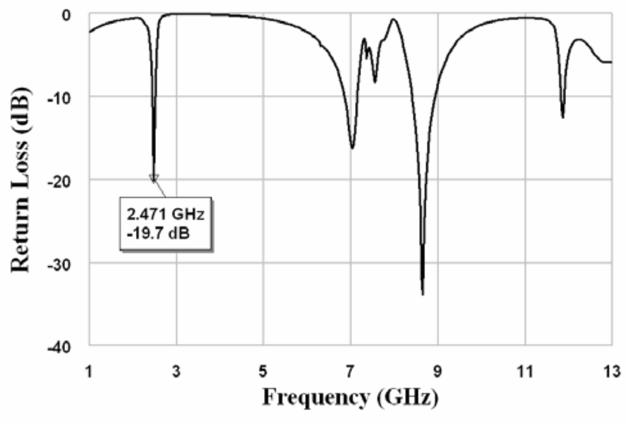


Figure-4. Simulated return loss of the proposed antenna with side length, *L* of 24.5 mm.

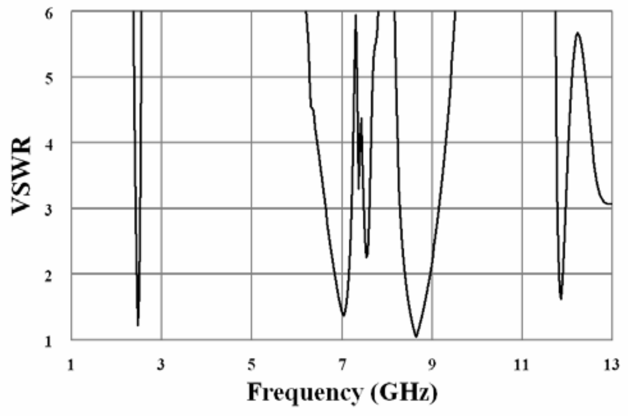


Figure-5. Simulated VSWR of the proposed antenna with side length, *L* of 24.5 mm.

Figure-6 shows an enlarged copy of Figure-4. The result of the return loss of the second iteration plusses fractal patch antenna design has a good result at frequency of 2.471GHz which is -19.7dB which could be considered as a good result. Where at the resonant frequency of 2.45GHz which is the intended desired frequency has a value of -12.1dB. This result could be considered as fine results. Table-1 shows these resonant frequencies, VSWR, and return loss (S_{11}) with bandwidth of each one.

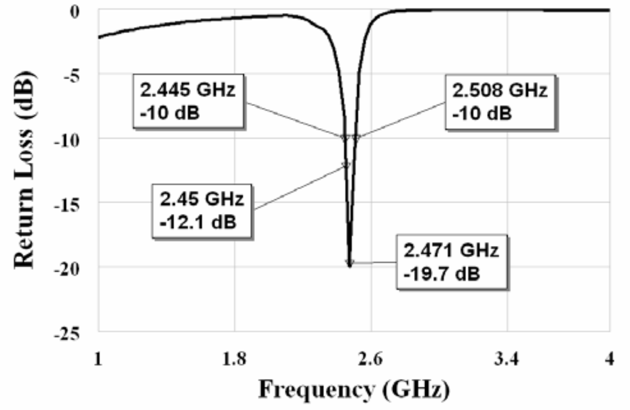
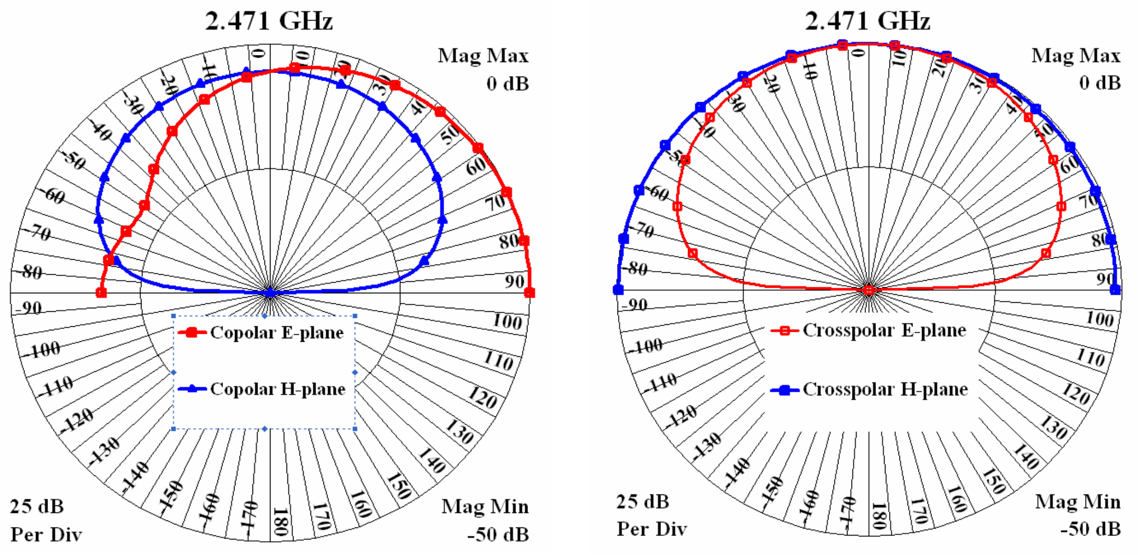


Figure-6. An enlarged copy of Figure-4. Simulated return loss at the first resonant, 2.471 GHz of the plusses antenna.

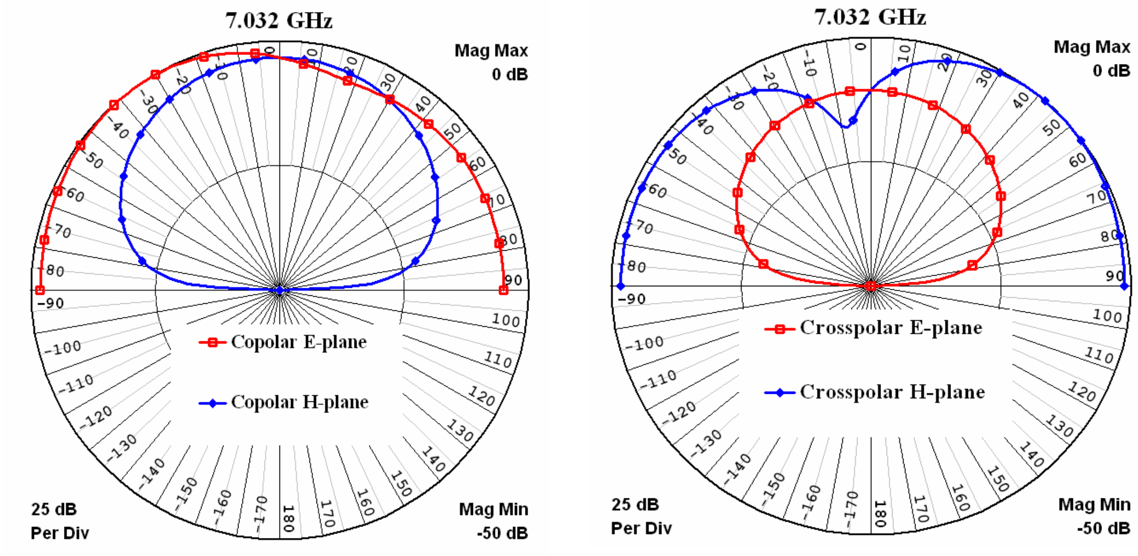
Table-1. Simulation results for proposed antenna.

Resonant frequencies (GHz)		**RL** (dB)	**VSWR**	**BW** (%)
f_{01}	2.471	-19.7	1.24	2.55
f_{02}	7.032	-16.2	1.37	4.18
f_{03}	8.651	-33.6	1.04	6.1
f_{04}	11.86	-12.5	1.62	0.6

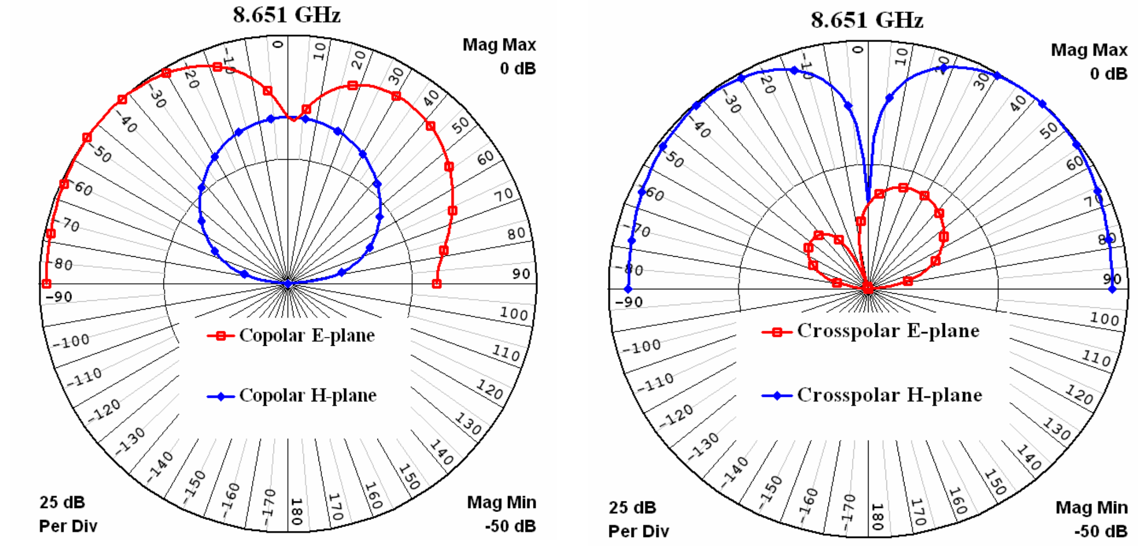
The radiation patterns at these resonant frequencies in copolar and cross-polar components in the E-plane and H-plane are shown in Figure-7.



(a) f_{01} = 2.471 GHz



(b) f_{02} = 7.032 GHz



(c) f_{03} = 8.651 GHz

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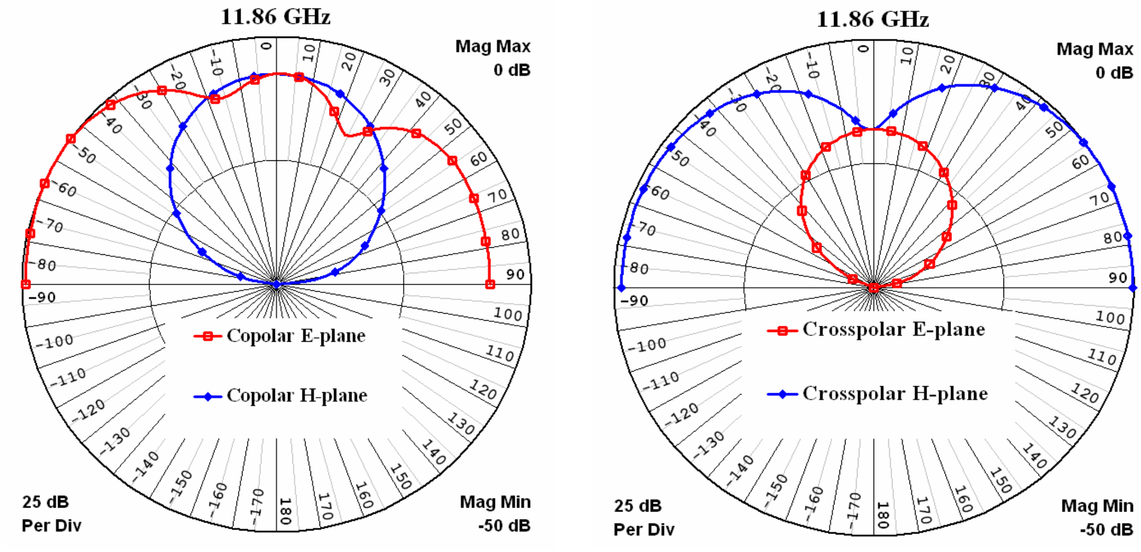

(d) f_{04} = 11.86 GHz

Figure-7. Radiation patterns of the modeled antenna at resonant frequencies of (a) 2.471 GHz (b) 7.032 GHz (c) 8.651 GHz (d) 11.86 GHz.

4. CONCLUSIONS

A new second iteration Plusses fractal patch microstrip antenna for multiband wireless communications systems has been designed. The proposed antenna structure showed high degree of self-similarity and space-filling property. The proposed antenna has four resonance bands at frequencies of 2.471 GHz, 7.032 GHz, 8.651GHz and 11.86 GHz, and at these frequencies the antenna has $S_{11} < -10$ dB (VSWR < 2). According to these frequencies this antenna can operate as a multiband antenna in the wireless applications.

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