ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 5, Issue 4, April 2018

CPW Fed Fractal Antenna for Multiband Applications

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***Abstract*— In this paper a novel fractal design technique for multiband antenna is presented. A coplanar waveguide (CPW) - fed circular patch is used to obtain the wideband characteristics. Applying the concept of fractal to antennas allows for multiband operation along with miniaturization. The antenna has been fabricated on an FR4 epoxy substrate with thickness 1.6mm and relative permittivity of 4.4. The simulations are performed using Ansoft HFSS and the results show that the proposed antenna can be used for different wireless communications.**

Index Terms:— Circular patch, Coplanar waveguide (CPW), Fractal.

INTRODUCTION

Today the wireless communication is one of the most vibrant areas in the communication field. In mobile communication systems number of different frequency bands are needed, such as global system for mobile communication (GSM800/900), personal communication system(PCS), GSM1800/1900, universal mobile telecommunication system (UMTS) and the industrial scientific and medical (ISM) band [1]. For the adaptability to these different scenarios in wireless communication systems the antenna that can operate at multiple frequency bands are required. Several research articles have been proposed for multiband operation using monopole antennas [2–4], slot antennas [5-7], fractal antennas [8–13], etc. A planar antenna that operate in GSM and UMTS frequency bands are proposed in [14] and from literature it is found that the lowest operation frequency of the antenna determines the overall size of the antenna.

In addition to multiband operation, it is essential that the antenna should have light weight, low profile and can be easily integrated with other microwave components.

Coplanar waveguide (CPW)-fed antennas have received much attention due to their many attractive features such as wide bandwidth, simple structure with single metallic layer and easy integration with monolithic microwave integrated circuits. Many CPW-fed antenna configurations have been proposed [15]-[19]. The circular monopole antenna exhibit wideband characteristics [20].

Fractal geometry have vital role in multiband and low profile antennas. The scaling and self-similarity properties of fractal antennas enable multiband and broadband properties as well as to miniature size of the antennas. The complex shapes and discontinuities of fractals lead to a larger bandwidth and

more effective radiation of antennas. Fractal structures are more reliable and have low cost than other conventional antennas. Several antenna structures have been designed using the fractal concept to achieve multiband behavior such as a Sierpinski gasket [21], modified Sierpinski [22], Minkowski fractal [23]-[24], triangular monopole with rectangular slots [25], and circular star triangular fractal-antenna [26].

In this paper, a CPW-fed fractal antenna for multiband applications is presented. The antenna offers good performance in the 1.7 – 2.48 GHz, 3.55 – 4.23 GHz and 4.9 – 5.93 GHz bands and is suitable for GSM 1800/1900, Bluetooth, IMT advanced systems and upper wireless local area network (WLAN), wireless fidelity (Wi-Fi) and worldwide interoperability for microwave access (Wi-MAX) applications. The lower bands are obtained without increasing the overall dimensions of the antenna which makes the proposed design compact. Section II presents the details of the antenna structure and fractal design. Section III discusses simulations and optimizations of antenna performance. The obtained results are discussed in section IV and conclusion is presented in Section V.

II. ANTENNA DESIGN

The Fig. 1 shows the geometrical evolution of the fractal antenna. The proposed fractal antenna is fed by a 50-Ω CPW and is printed on the FR4 epoxy substrate of relative permittivity 4.4 and loss tangent tan $\delta= 0.02$ with thickness of h =1.6mm.

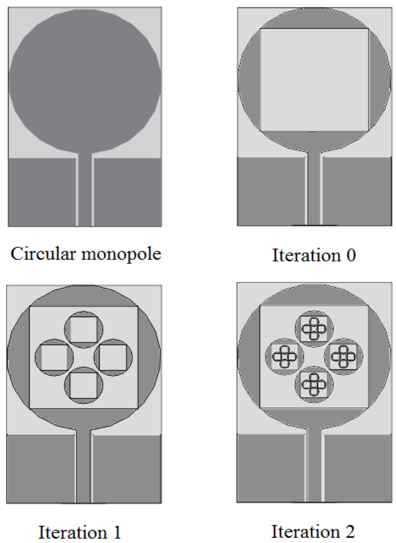

Fig. 1 Geometrical evolution of proposed antenna

The final optimized antenna is shown in Fig. 2. The CPW-feed line of width Wf is spaced at a distance ‘g’ from the ground plane of dimension Lg × Wg on both sides. The circular patch of diameter D is placed at a distance ‘s’ from the ground plane. The base fractal is designed by cutting a square shaped slot from the circular patch.

The first iteration of the proposed antenna is designed by scaling the base structure and arranging it along the sides of the square. The second iteration is obtained by repeating the pattern within each square. The parametric values of the proposed antenna are shown in Table I.

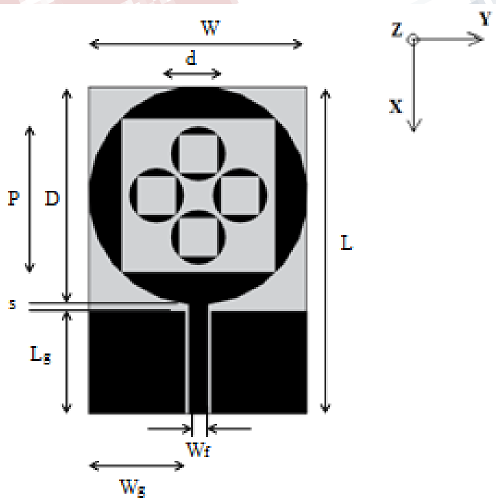

Fig. 2 Proposed antenna structure

Table 1 Parametric values of the proposed antenna

Parameter	Size(mm)
L	51
W	34
D	34
P	24
L_g	16
W_g	15
g	0.5
W_f	3
s	1
d	8.5

III. SIMULATIONS AND OPTIMIZATIONS

The simulation and optimization is performed by Ansoft High Frequency Structure Simulator (HFSS v13) software. Fig. 3 shows the simulated return loss variations for different iterations. The Return Loss (RL) is a parameter which indicates the amount of power that is lost to the load and does not return as a reflection. The basic circular patch antenna provides wideband characteristics. Multiband operation is achieved by inserting a fractal pattern in this structure.

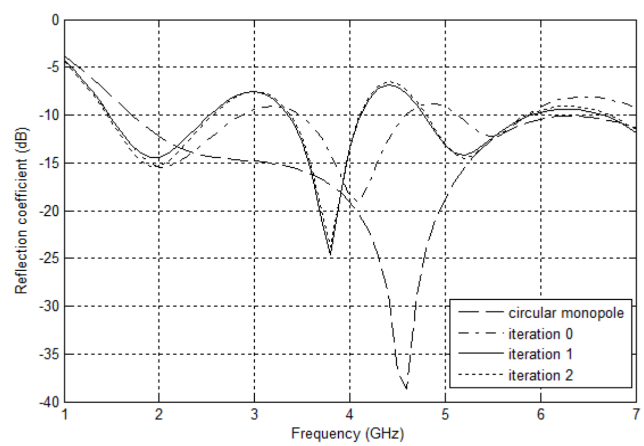

Fig. 3 Return loss of proposed antenna structure for various iterations

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The second iteration is not considered further since results obtained from the second iteration did not vary significantly from that of first iteration. It is also evident that the fabrication of iteration 2 structure is difficult.

The iteration factor for the proposed design was optimized by simulating the S11 results with different scaling factors using Ansoft HFSS and is shown in Fig. 4. To get desired fractal geometry the iteration factor for this design is taken to be the one-fourth of the original shape.

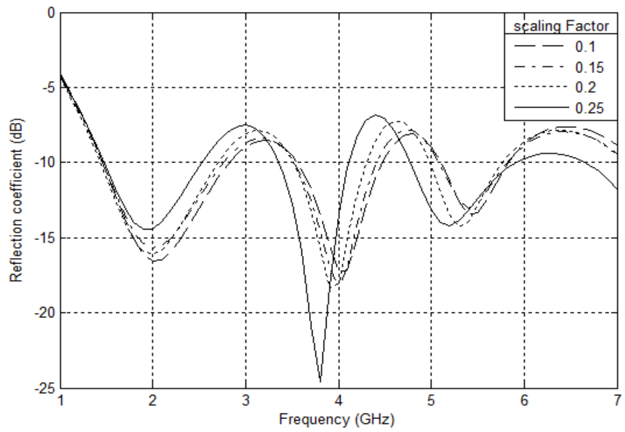

Fig. 4 Return loss for different scaling factors

The proposed multiband antenna was designed and simulated on different substrates having different relative permittivity and thickness. The simulated return loss is shown in Fig. 5. The antenna exhibits triple band behavior on all the substrates.

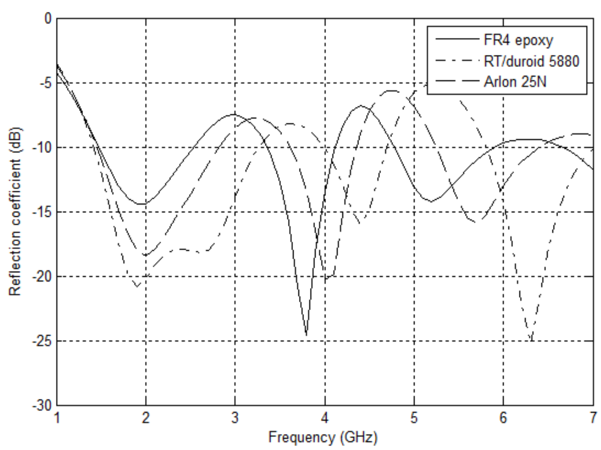

Fig. 5 Return loss of proposed antenna on different substrates

IV. RESULTS

The simulated and measured return loss of the proposed antenna shown in Fig. 6. The measurements are carried out on N9915A network analyzer. Except the soldering effects of the SMA connector, which have been neglected in the simulations the fabricated structure still exhibits triple band behavior. Comparison between simulated and measured return losses are summarized in Table II.

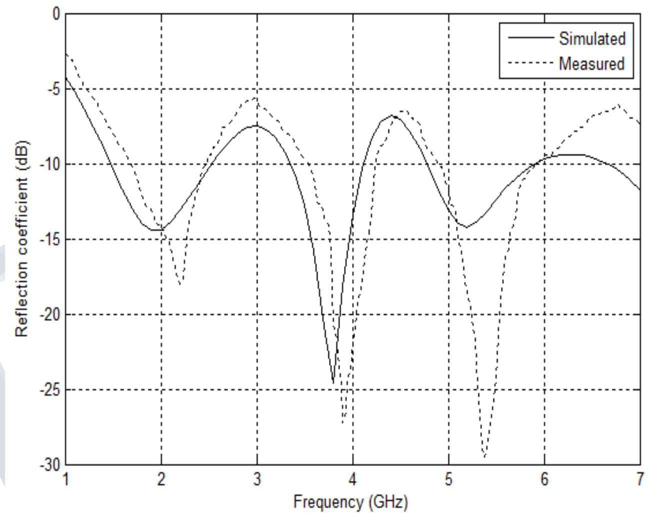

Fig. 6 Return loss of proposed antenna

Table II. Comparison between simulated and measured return losses

Operating frequency		First	Second	Third
Resonant frequency (GHz)	Simulated results	2	3.8	5.2
	Measured results	2.2	3.9	5.38
Return loss (dB)	Simulated results	-14.42	-24.63	-14.24
	Measured results	-18.03	-27.23	-29.55

For the antenna to work efficiently, the acceptable value of return loss is below -10dB and that of VSWR is less than 2. The VSWR of designed antenna is illustrated in Fig. 7.

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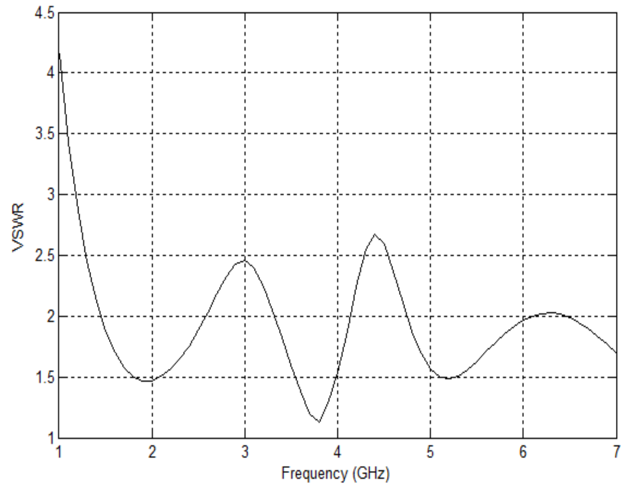

Fig. 7 VSWR of proposed antenna

The radiation patterns in the E and the H planes measured at 2 GHz, 3.8 GHz and 5.2 GHz are shown in Fig. 8. The antenna displays a dipole-like radiation pattern in the E-plane with half power beam width (HPBW) of 83.08°, 55.24° and 60.50° at the above three resonant frequencies respectively and a nearly omnidirectional radiation pattern in the H-plane.

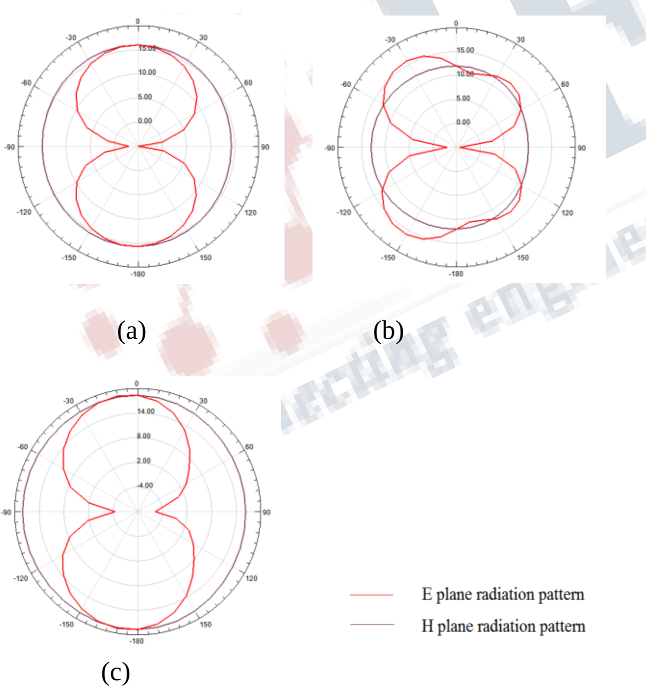

Fig. 8 Radiation pattern of proposed antenna at (a) 2 GHz (b) 3.8 GHz (c) 5.2 GHz

The good radiation pattern stability and the omnidirectional radiation performance make the proposed antenna suitable for applications in wireless devices.
A photograph of the fabricated antenna is shown in Fig. 9.

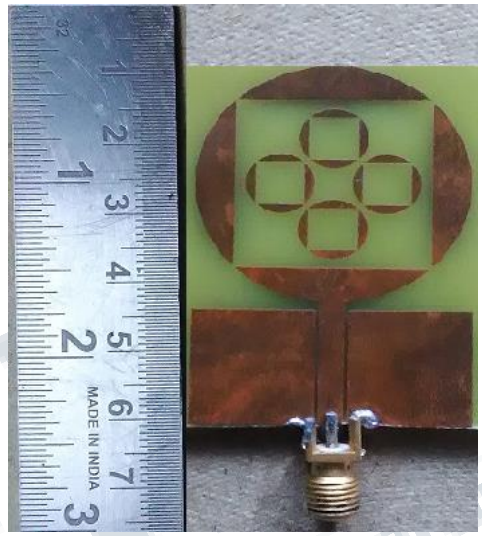

Fig. 9 Photograph of fabricated antenna

The features of the antenna are compared with a few recently reported antennas are shown in Table III. On comparing the proposed antenna with some of the recently proposed multiband antennas, the designed antenna is found to be compact and design is simple.

Table III Comparison between recently reported antennas and the proposed antenna

Antenna	Number of operating bands	Antenna Size (mm^3)	Feeding Technique
Proposed antenna	3	34×51×1.6	CPW feed line
[7]	2	72×84×1.6	Microstrip feed line
[10]	2	80×80×1.56	Co-ax probe feeding
[22]	2	96 ×72 × 1.5	Microstrip feed line
[24]	3	59×90×1.6	Microstrip feed line

V. CONCLUSION

A CPW fed fractal antenna for multiband applications has been introduced. The designed antenna is simulated using Ansoft HFSS. On analyzing the simulated results it shows that the designed antenna exhibits good performance in three bands which makes it is suitable for GSM 1800/1900, Bluetooth, and IMT advanced systems and upper WLAN, Wi-Fi and Wi-MAX applications.

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