Research Journal of Applied Sciences, Engineering and Technology 7(10): 2022-2026, 2014
DOI:10.19026/ajfst.7.494
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: June 22, 2013 Accepted: July 09, 2013 Published: March 15, 2014

Research Article

Analysis of Fractal Antenna for Ultra Wideband Application

N.M. Sahar, M.T. Islam and N. Misran
Faculty of Engineering and Built Environment, National University of Malaysia,
43600 UKM Bangi, Selangor, Malaysia

Abstract: Aims of this study are to design a simple and compact microstrip-fed Ultra Wide Band (UWB) printed fractal antenna and analyze the performance of the antenna for different iterations. A second iteration of a triangle patch antenna is proposed to perform UWB. Based on the result, the proposed antenna occupies about 6.73 GHz bandwidth covering 3.52-10.24 GHz. The bandwidth is increased about 54.15% for the first iteration of proposed antenna and 69.5% increased for second iteration. A radiation pattern in H-plane and E-plane is also obtained. H-plane of radiation pattern is performed as omni directional and E-plane perfomed like a dipole antenna. Coplanar wave guide is approached to obtain ultra wideband.

Keywords: Fractal antenna, planar antenna, printed antenna, Ultra Wide Band (UWB), wireless communications

INTRODUCTION

Fractal technique is adopted to improve the bandwidth of the antenna in comparison to its non fractal counterpart (Anirban *et al*., 2013). Also, fractal structure is approached in this design for miniaturization and multiband characteristics (Romeu and Soler, 2001). Many types of fractal antenna have been proposed such as Sierpinski, Koch and Minskowki geometry for wireless applications (Puente *et al*., 2000). By doing iterations dimension, the performance of the antenna are affected. The fractal antenna has the advantage on enhancing bandwidth, hence it can be used in Ultra Wideband UWB application (Mohammad *et al*., 2013), besides the multi-fractal antenna has better impedance bandwidth and return loss characteristics than the conventional antenna was proposed in Basil *et al*. (2013). It can be seen that greater demand is created by means of quick growth of wireless communications and electronics for wireless devices that can obey different rules at different standards (Azim *et al*., 2011, 2012; Islam *et al*., 2010a; Habib Ullah *et al*., 2012; Mobashsher *et al*., 2011; Ullah *et al*., 2012; Tiang *et al*., 2011). It also the paved the way for wide usage of mobile phones in modern society resulting in mounting concerns surrounding its harmful radiation (Faruque *et al*., 2010a, b, 2011, 2012a, b; Islam *et al*., 2010b). The Koch-like sided Sierpinski multi-fractal antenna fractal techniques are been incorporated in the patch to obtain the multi-fractal UWB antenna that achieved an operating bandwith ranging from 3.84-5.7 GHz.

In Shresta *et al*. (2013), miniaturization of micro-strip patch antenna by incorporating fractal geometry was presented. The unique space-filling property of fractals is explored to develop a novel patch antenna operating at 2.45 GHz with significant size reduction than its conventional counterpart by etching the rectangular microstrip patch as Sierpinski carpet in modified form of different iteration orders. Fractal techniques approaches for multiband characteristics was proposed in Siva *et al*. (2013). The volume of the Sierpinski triangle antenna manages X band (8-12 GHz), Ku band (12-18 GHz) and K band (18-26.5 GHz) of frequencies. In addition, different feeding methodologies can be applied on fractal antenna without effect performance for UWB such as micro-strip line and Coplanar Waveguide (CPW). In Naser-Moghadasi *et al*. (2013), a compact Coplanar Waveguide (CPW) monopole was presented as UWB application that achieved a frequency band from 2.94-11.17 GHz.

In this study a new Koch Fractal antenna is proposed for ultra wideband communication system. The performace of bandwith and radiation pattern of E-plane and H-plane of three different antenna are studied and compared. Section two describes about the geometry and dimensions of the proposed antenna. In section three we explained about results and discussion. Section four explains about conclusion.

ANTENNA DESIGN

The proposed antenna structure composed of a triangle patch. The configuration is made of iterations

Corresponding Author: N.M. Sahar, Faculty of Engineering and Built Environment, National University of Malaysia, 43600 UKM Bangi, Selangor, Malaysia

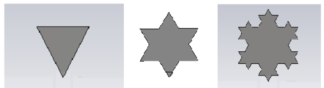

Fig. 1: Three iterations of the koch fractal

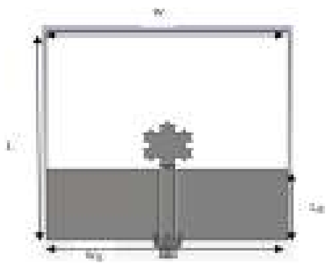

Fig. 2: Koch fractal antenna for 2nd iteration

Table 1: Optimized parameters of the proposed antenna

Parameter	Value (mm)
L	50
W	50
Lg	17
Wg	48
Gap	1

of a triangle patch, up to third iterations. Fractals defined as interactive techniques resulting in self similar characteristics. Koch curve in first iteration is approached in this proposed antenna. The total length of the Koch curve is given by:

$$L_{Koch} = L_o \left(\frac{4}{3}\right)^n \quad (1)$$

where,
L_{koch} = Total length of koch curve
L_o = Length of initiator

Koch antenna with the increase in the iteration the surface of the radiating patch decreases, the perimeter of the patch increases and the resonant frequency starts to decrease (Mirzapour and Hassani, 2008). This fractal antenna can be modelled via (2):

$$S_{i+1} = S_i - \frac{3\sqrt{3} \times 4^{i-2}}{2} \left(\frac{R}{3^{i-1}}\right)^2 \quad (2)$$

$$L_i = 6R \left(\frac{4}{3}\right)^{i-1} \quad (3)$$

$$i = 1, 2, \ldots\ldots, \ N$$

where, R is the length of one side of the equilateral triangle as shown in Fig. 1, S_i the surface area and L_i the periphery of the radiating patch for the i^{th} iteration. For the first iteration:

$$S_1 = 3R^2 \sqrt{3/2} \quad (4)$$

$$L_1 = 6R \quad (5)$$

A fractal antenna structure should be symmetrical about a point and it can be self similar with similar appearance at each and every scale.

The proposed antenna is designed on Fire Retardant-4 board (FR4) dimension 50×50 mm which is has a relative dielectric constant of ε_r = 4.7 with tangent loss of 0.019 andit has a 1.6 mm substrate thickness and a 0.035 mm copper thickness. The reasons for choosing this type of board are because of the low cost and ease of fabrication. The configuration of the proposed antenna is shown in Fig. 2 where the ground plane is Wg = 48 mm and the length side, Lg = 17 mm. A gap between the ground and the transmission is about 1 mm (Table 1).

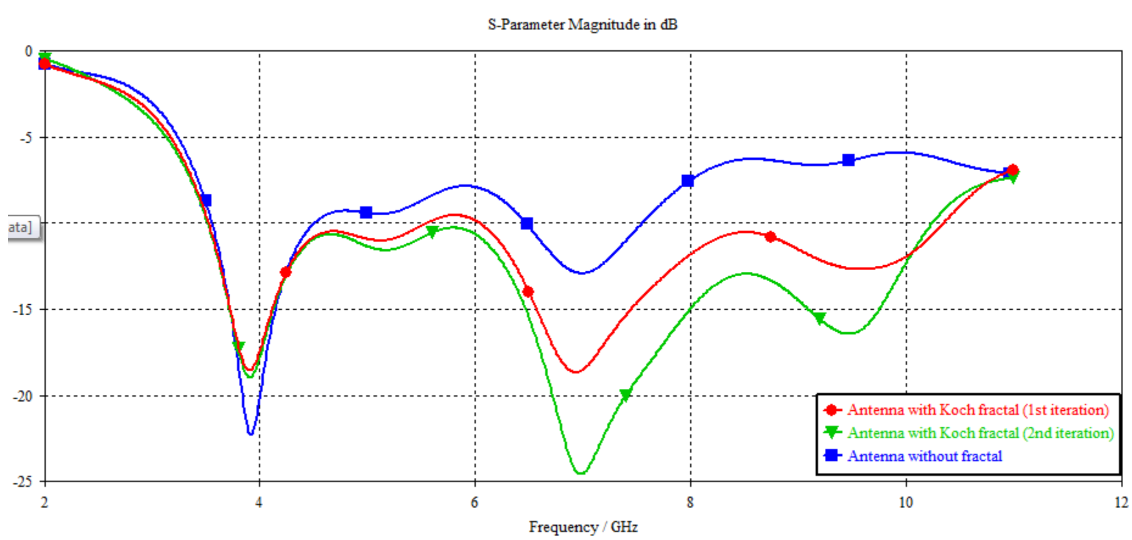

Fig. 3: Return loss for three iteration of the proposed antenna

Table 2: The performance of koch fractal 2nd iteration antenna (within 2-12 GHz)

	Frequency band (GHz)	Bandwidth (GHz)	Frequency band	Bandwidth (GHz)
Antenna without fractal	3.54-4.48	0.940	6.46-7.54	1.08
Antenna with koch fractal (1st iteration)	3.52-5.57	2.050	5.98-10.35	4.36
Antenna with koch fractal (2nd iteration)	3.52-10.24	6.672		

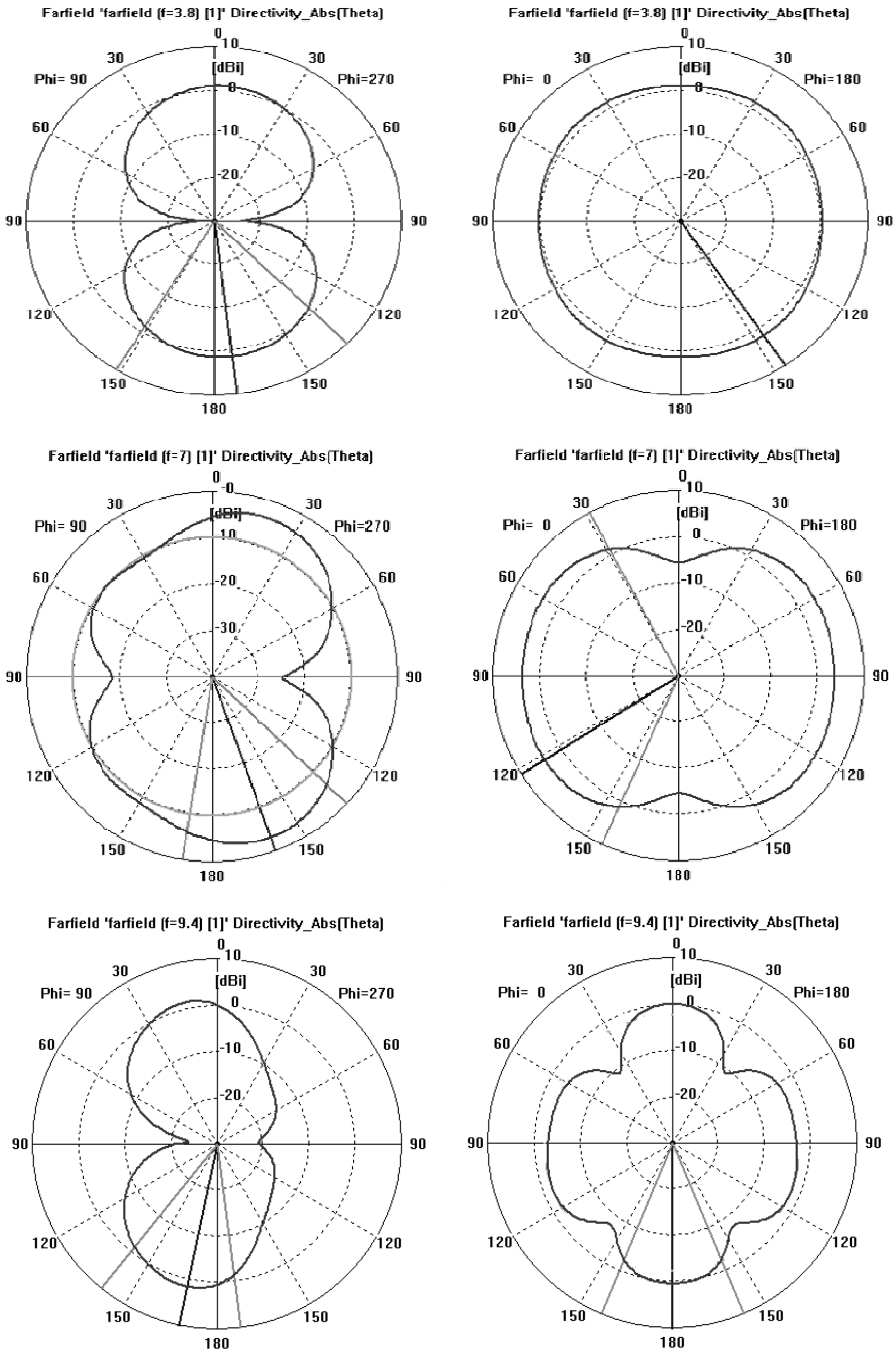

Fig. 4: Radiation patterns in H-plane and E-plane at 3.8,7 and 9.4 GHz, respectively

RESULTS AND DISCUSSION

The characteristics of the proposed antenna have been analyzed by Computer Simulation Technology, CST software. The performances of the antenna have been compared based on the simulated result from three different antennas as shown in Fig. 3. From the original antenna which is a triangle antenna, it is performed dual band. First band from 3.54 to 4.48 GHz with bandwidth is 0.94 GHz and for second band the range is from 6.46 to7.54 GHz with the bandwith is 1.08 GHz. After doing first iteration, the bandwitdth of both dual is increased where the bandwith for first band is 2.05 GHz (3.52-5.57 GHz) and second band is 4.36 GHz with the range is 5.98 to 10.35 GHz. For second iteration, the antenna covers 6.73 GHz bandwidth with operated frequency ranging from 3.52 to 10.24 GHz which almost completely satisfies the UWB system requirement.

Table 2 shows the performance of proposed antenna by selecting three operated frequency from the lowest return loss which are at 3.8, 7 and 9.4 GHz, respectively. The radiation pattern of the proposed antenna are also measured at this three resonance frequencies are shown in Fig. 4. The co-polarized radiation pattern in H-planes are omnidirectional and for E plane, the radiation pattern is alike dipole. At 7 GHz, the two nulls is distorted the radiation pattern for E-plane and H-plane. Moreover, 4 nulls has been introduced at 9.4 GHz.

CONCLUSION

A second iteration of Koch fractal antenna has been proposed for ultra wideband applications. The iteration of Koch fractal antenna helps to achieve wide impedance bandwidth. It is observed from antenna performance that the proposed antenna achieved a ultra wideband ranging from 3.52-10.24 GHz with the bandwidth is 6.72 GHz. As the result, there is 54.15% increment of bandwith after doing first iteration of proposed antenna. For second iteration, the bandwidth perfoms 69.5% increased. It is shown that the antenna with higher iterations exhibits better bandwidth. This antenna can be applied for many applications such as wireless communication.

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