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Design and fabrication of a fractal multiband patch antenna for IEEE WLAN applications

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ABSTRACT

A multiband patch antenna based on new Fractal geometry is proposed for IEEE standard WLAN application. The antenna resonates at three different frequency bands i.e 5.192 GHz, 5.782 GHz and 8.186 GHz having a bandwidth of 499 MHz, 220 MHz and 522 MHz respectively. In this paper, the antenna's parameters such as return loss, bandwidth, gain and radiation pattern are analyzed by Ansoft HFSS EM simulator. The simulated results have been compared with the measured result, which shows an excellent accord between each other. The proposed antenna shows an improvement when compared with other antennas of similar application.

Keywords: patch antenna; fractal geometry; multiband antenna; WLAN.

1. INTRODUCTION

During the last decade, it has been observed that there is fast development in multiband microstrip antenna due to its broad application in many communication systems. Some of the main applications of this type of antennas are in Wireless Local Area Network having a frequency range of 2.4 GHz to 5 GHz.

During recent period, the fractal geometries are very rapidly used for the desigining of multiband antennas, which are not possible with traditional approach of antenna design. Microstrip antennas are one of the primary choice for such antennas, mainly because of their lightweight and low-profile characteristics [1-4], but they often suffer from intrinsically low gain. The miniaturization and multiband or broadband characteristics or both for an antenna can be attained by combining fractal geometry with conventional patch antennas. The dual band antennas has been designed for WLAN applications with good bandwidth and gain [5-7]. It has been shown that by adjusting the coupling between the extended ground plane of the PCB and the antenna, the operational frequency and bandwidth can be changed [8].

Many fractal antennas have been observed during the recent past which are having different shapes and characteristics [9-12]. The Peano fractal geometry patch antennas is investigated in [11] and compare itsperformance with those of the usual fractals geometry, such as Koch, Tee-Type and Sierpinski. Another probe fed E-shape fractal patch antenna (EFPA) for hepta band has been proposed and analysed in [12].

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2. DESIGN CONFIGURATION

2.1. Antenna Fractal Geometry

In the proposed antenna design, a new fractal shape is used which is based on Koch Fractal geometry. The Koch Fractal geometry is widely used for antenna design in telecommunication systems such as wireless LAN, mobile devices, etc. The geometric construction of this new fractal shape beginsby a straight line, called the initiator (n = 0), which is shown in Fig-1(a). This is partitioned in to four equal parts, and the two centric segments are replaced with four others of the same length with the indentation angle $\Theta = 60°$as shown in Fig-1(b) for n = 1, as the first iteration. This is the first iterated version of the new fractal geometry and is called the generator. The proposed fractal geometry is applied on the perimeter of the slot created from patch.

(a)

(b)

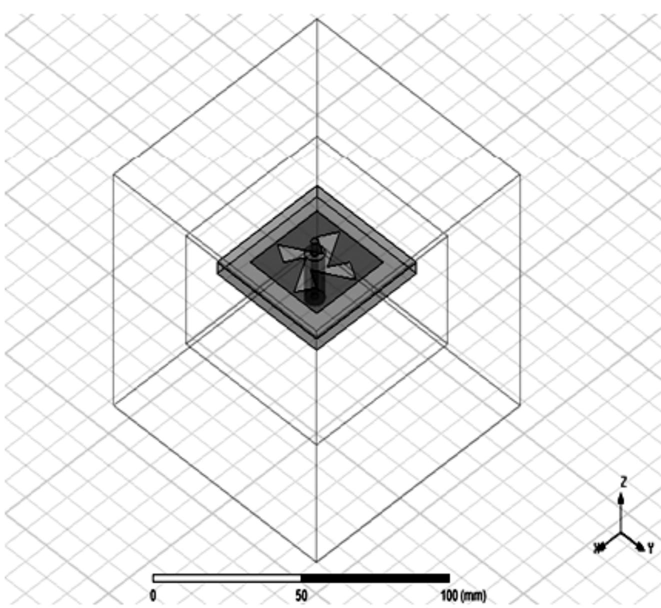
Figure 1: (a) Initiator for n = 0 and (b)Generator for n = 1.

2.2. Substrate used

In the proposed design, widely available FR4 substrate is used whose dielectric constant and loss tangent having a value of 4.4 and 0.02 respectively. For achieving high bandwidth, the thickness of FR4 substrate is taken as 3.2mm. The dimensions of the square substrate are taken as $48mm^2$.

2.3. Patch Width and Length

For the proposed design, the initial length and width of the patch having a dimension of 32×32mm is taken and then a new fractal shape is implemented on the proposed antenna design and the process is repeated for



(a)

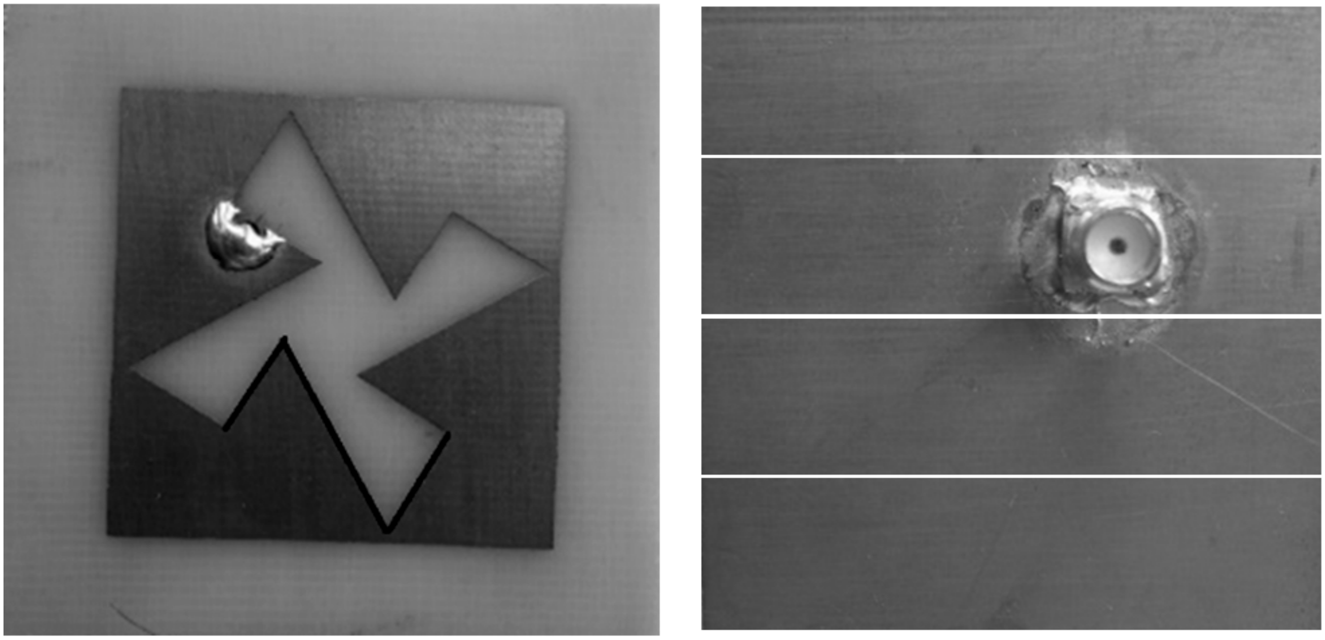


Figure 2: (a) HFSS Design (b) Fabricated antenna front (c) Fabricated antenna back (SMA connector for RF feed)

higher iteration. The fractal geometries usually clarify with an iterative function system (IFS). This new fractal geometry consists of repeated of the series of IFS affine transformationsas shown in fig-2.

2.4. Feed Point Location

The location of the feed point is optimized by parametric analysisfor getting a desired impedance matching. In this design, co-axial probe feed is used to excite the antenna. The location of the feed point is -6 mm, -7 mm, 0 along the rectangular co-ordinate system which is perfectly matched with its input impedance.The outer conductor of the coaxial cable is connected to the ground plane.

3. SIMULATION RESULTS

Figure-3 shows the simulated gain pattern of the proposed antenna at a frequency band of 5.2965 GHz and it has been obseved that the gain is sufficient for the WLAN application.

Name	Theta	Ang	Mag
m1	48.0000	48.0000	4.5177
m2	-48.0000	-48.0000	3.2269

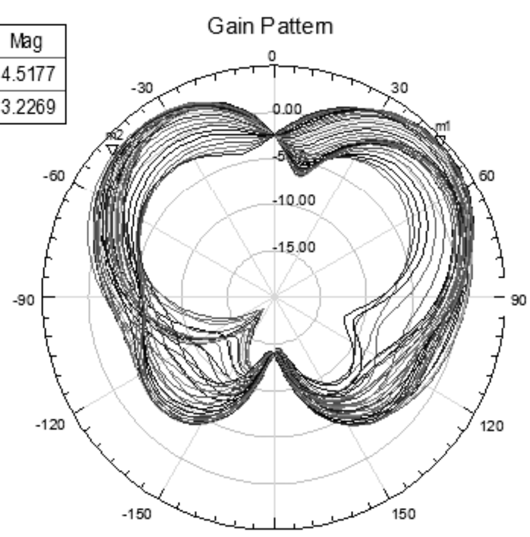


Figure 3: Gain pattern of the proposed antenna for 5.2965 GHz frequency

3.1. Radiation Pattern

The 3-D polar plot of the proposed antenna at a frequency band of 5.2965 GHz is shown in the figure-4.

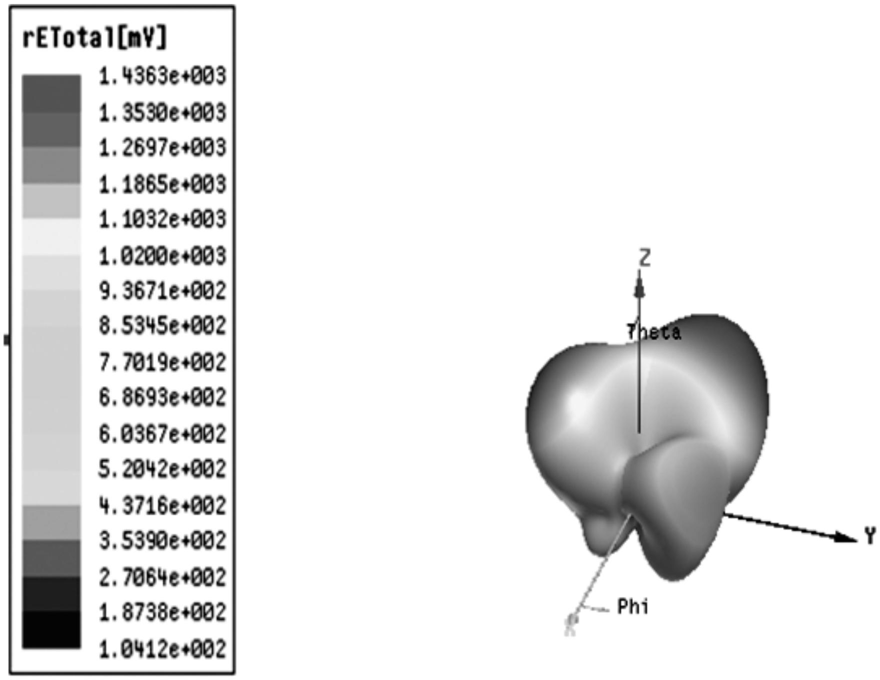


Figure 4: -3-D polar plot of the proposed antenna for 5.2965 GHz frequency

Table 1
Proposed antenna Parameters

Freq. Bands	*Resonant frequency*	*Return Loss*	*Bandwidth*	*VSWR*	*Gain*
I	5.29 GHz	-19 dB	0.081 GHz	1.23	4.51
II	5.882GHz	-18 dB	0.352 GHz	1.24	4.62
III	8.28 GHz	-21 dB	0.637 GHz	1.22	5.48

3.2. Measured Result

The measured results are taken fromthe Anrtisu network Analyzer having model number is MS46322A for frequency range from 1 MHz to 4/8/14/20/30/43.5 GHz. Antenna under test is shown in figure-5.

Figure 5: antenna under testing using network analyzer

It has been observed from measured results that the antenna resonates at 5.192 GHz, 5.782 GHz and 8.186 GHz having a bandwidth of 499 MHz, 220 MHz and 522 MHz respectively. The value of VSWR is satisfactory for the proposed antenna.

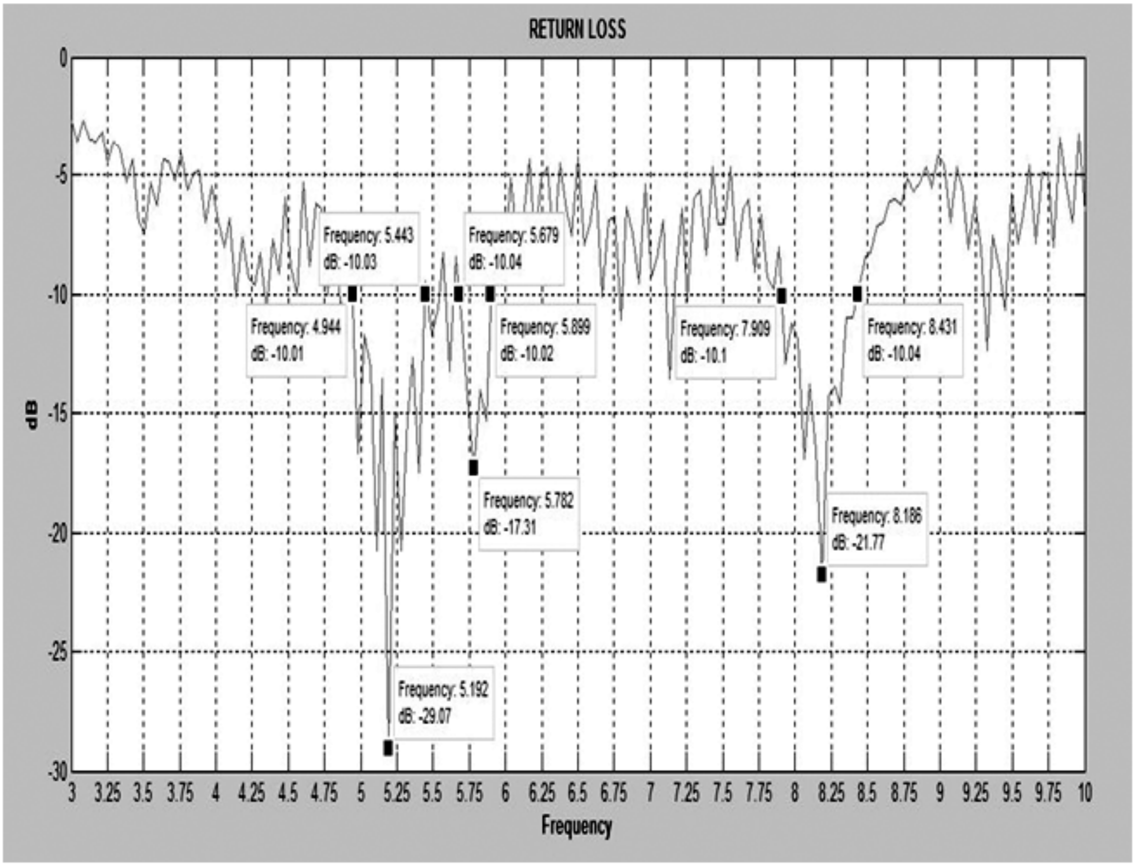


Figure 6: Return loss measured experimentally

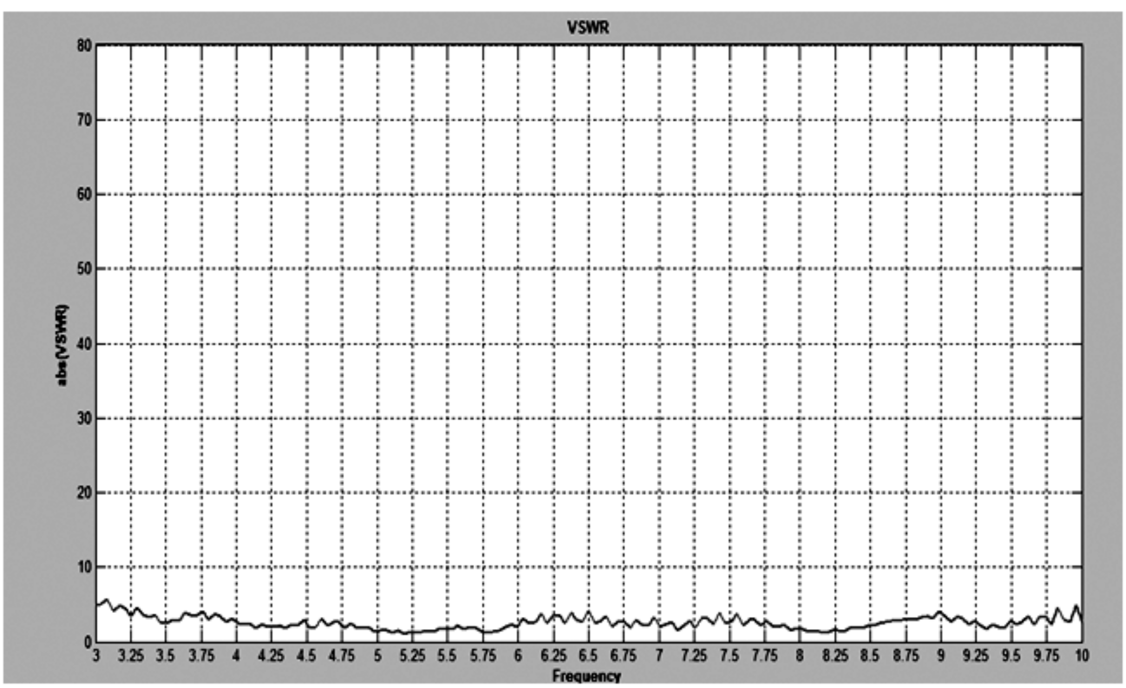


Figure 7: VSWR measured experimentally

Comparison of proposed antenna and reference antennas that operates at approximately same frequency range and application are shown in table 2. It has been observed from table 2 that the proposed antennahas better results in terms of bandwidth, return loss. The simulated gain of the proposed antenna varies from 4.51 dBi to 5.48 dBi.

Table 2
Comparison Proposed and Reference antenna parameters

Antenna		*Resonant Freq.*	*Return Loss*	*Bandwidth (MHz)*
Proposed Antenna	Band-I	5.192GHz	-29.07dB	499
	Band-II	5.782GHz	-17.31dB	220
	Band-III	8.186GHz	-21.77dB	522
Ref. [7]	Band-I	5.255GHz	-14dB	270
	Band-II	5.808GHz	-25dB	260
Ref. [6]	Band-I	2.45GHz	-25 dB	80
Ref. [8]	Band-I	2.44 GHz	-16.0587	80
	Band-II	5.20 GHz	-16.0587	200

4. CONCLUSION

The Proposed antenna resonates at three different frequency band i.e 5.19 GHz, 5.78 GHz and 8.18 GHz.The band I, II and III are useful for indoor WLAN application,IEEE WLAN application andVSAT uplink frequncy respectively. Thus the proposed antenna is capable to fullfill the demand of multiple application.

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