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Design of I Shape Fractal Antenna for WLAN and WiMAX Applications

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Abstract: In this paper, I shaped fractal antenna for WLAN and WiMAX applications is proposed. Antenna is designed and simulated by using FR4 substrate, the design is a fractal antenna with modified ground structure. The proposed antenna has been designed with scaling factor of one-third. Fractal antennas are found to be advantageous because of their small size and multiband functionality. The design and simulation of the antenna is carried out using CST microwave Studio simulation software. The simulated results present good performances in term of radiation pattern and matching input impedance. This antenna is suitable for WLAN and WiMAX.

Keywords: Flame Retardant 4(FR4), Fractal Antenna, Computer Simulation Technology (CST), WiMAX, WLAN.

I. INTRODUCTION

In today's wireless communication, antennas are required which gave higher performance, higher gain, wider bandwidth, multiband support. They should be of low cost and conventionally smaller design dimensions. To fulfil these requirements Fractal Antennas are discovered. The fractal term was coined in 1975 by, Benoit B. Mandelbrot who is a French mathematician.
The fractal shape is associated to a partial defected ground structure, due to which it produces multi band behaviour. A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is a reduced-size copy of the whole.

Fractals have the following features.
1. It has a fine structure at arbitrarily small scales.
2. It is too irregular to be easily described in traditional.
3. Euclidean geometric.
4. It is self-similar.
5. Simple and recursive

The fractal theory approach has been used as a size compression technique for all types of antennas such as dipoles, loops, patches and so on leading to the development of fractal antenna. Due to Fractal geometry, creating of antenna is possible which can work at multiband frequencies which avoids interference.

The geometry of fractal is important because the effective length of the fractal antennas can be increased while keeping the same total area. The shape of the fractal antenna can be formed by an iterative mathematical process, called as iterative function systems IFS.

Fractals are known as infinitely complex because of its similarity at all levels of magnification. There are only two types of fractals, natural fractals and mathematical fractals. Examples of natural fractals are: coastlines, lightning, earthquakes, plants, vegetables, rivers, clouds, galaxies all these examples have fractal geometry. The mathematical fractal geometry has been known for a century and these are based in equations that undergo iterative process. Examples of these mathematical structures are: von Koch snowflake, the Mandelbrot set, Sierpinski carpet, the Lorenz attractor, and the Minkowski curve. Here we are using I shaped fractal antenna which is designed up to second iteration, which gives some desirable result for many wireless applications.
Fractal geometries have two common properties: self-similar property, space filling property. The self-similarity property of certain fractals results in multiband behavior. While using space filling properties, fractal makes reduce antenna size.

II. ANTENNA DESIGN SPECIFICATIONS

The same antenna used for different bands requires the antenna to be a multiband antenna and could be operated at different frequencies. The design of second iterated antenna is shown in figure1. The length and width of substrate are taken as 47.6218 mm. The Antenna is fabricated on FR-4 material having dielectric constant 4.4 and height of the substrate is 1.6 mm. The length and width of antenna are taken as 37.6218 mm. Microstrip feed line is used for feeding. The simulation results show that the antenna fulfils the requirement of WiMAX and WLAN range.

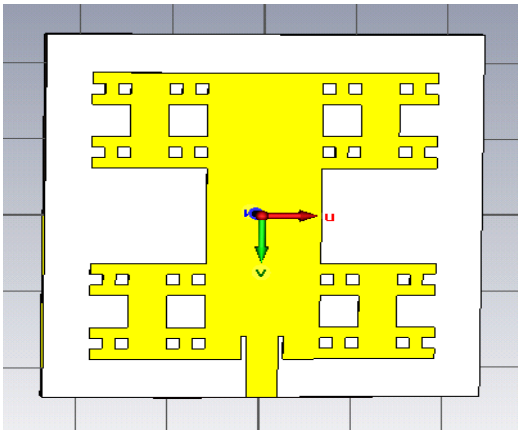

Figure1. Front view of 2nd iterated antenna by CST software

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Partial ground plane with rectangular slot is used. Making a rectangular notch behind the feed line in ground plane and narrow rectangular slit in ground results in drastically improvement in the return loss curve. This is a simulation based study. The design and simulation of the antenna is carried out using CST microwave Studio simulation software.

Parameter	Descriptions	Value
Ls	Length of substrate	47.6218
Ws	Width of substrate	47.6218
h	Height of substrate	1.6
L	Length of patch	37.6218
W	Width of patch	37.6218
Lf	Length of feed line	9
Wf	Width of feed line	3
Lg	Length of ground plane	47.6218
Wg	Width of ground plane	23.8109
Lsl	Length of empty slot	10
Wsl	Width of empty slot	8
a	Length and Width of slot in 1st iteration	12.5406
b	Length and Width of slot in 2nd iteration	4.1802
c	Length and Width of slot in 3rd iteration	1.3934

Table 1 Dimension of proposed antenna design (in mm)

III. ANTENNA DESIGN PROCEDURE

In this paper I-Shaped Patch is taken as a base shape. I-shaped geometry has been applied to micro-strip patch antenna to reduce its overall size.
The construction of our design begins with designing a patch (W =37.6218 mm, L=37.6218mm) and in 0th iteration I-shape is created by removing two square from patch antenna. In the 1st iteration the 8 square are cut from I-shape by 3-by-3 grade. The same procedure is then applied to cut 32 squares from 2nd iterated antenna to get final antenna. Iteration is done by taking one third of second sub squares. Length of feed line is 9 mm and width is 3.44 mm. Figures from 2 to 4 shows the above steps.

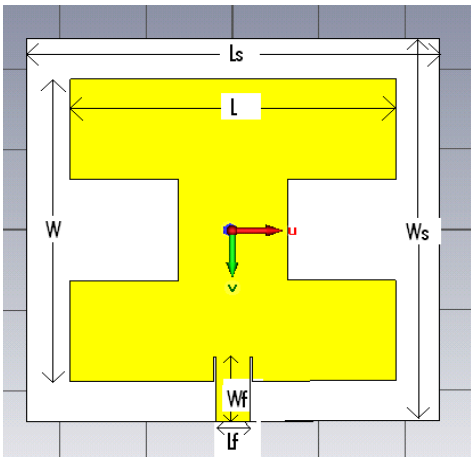

Figure2. Front view of 0th iterated antenna by CST software

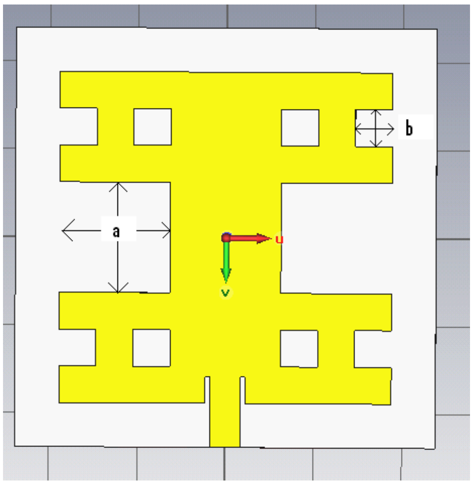

Figure3. Front view of 1st iterated antenna by CST software

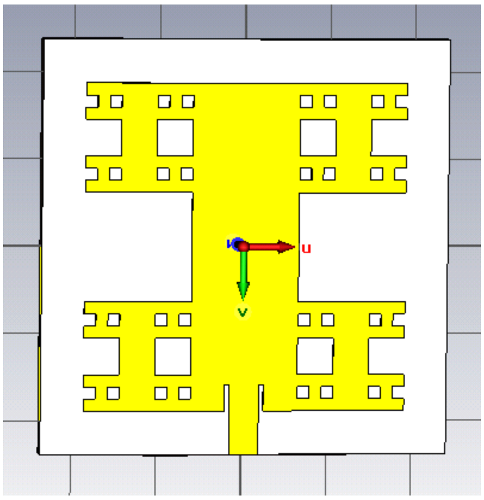

Figure4. Front view of 2nd iterated antenna by CST software

The width of ground plane is 23.8109 mm and length is 47.6218 mm. Length of empty slot is 8 mm and width of empty slot in ground plane is 10 mm. Figure 5 shows the view of ground plane.

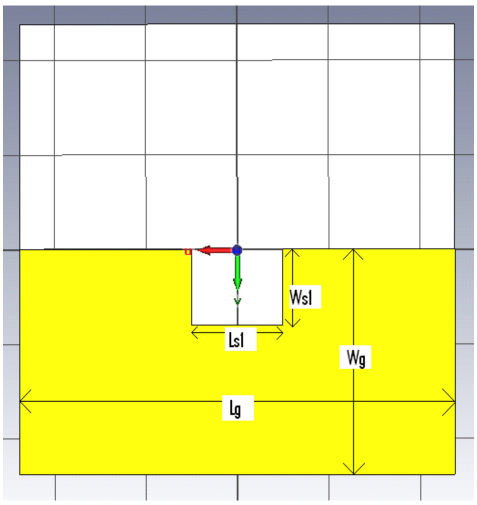

Figure5. Back view of antenna by CST software

IV. SIMULATION RESULTS

The s11 vs. frequency curve with the optimized values is shown below. The return loss curve for 4.06 GHz shows a minimum S11 -21.96dB at 4.14 GHz and return loss curve for 5.218 GHz shows a minimum S11 -22.48dB at 5.218 GHz. This shows that the proposed antenna covers the both the bands.

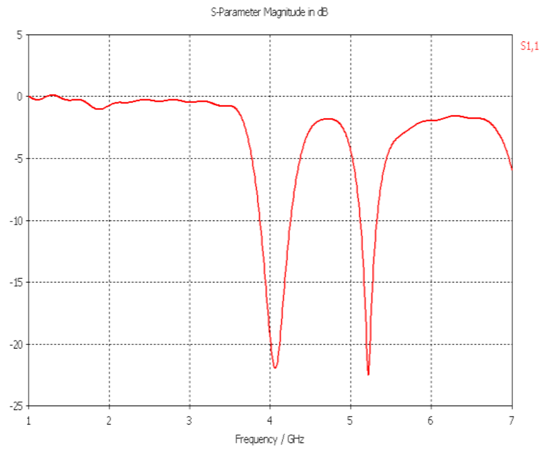

Figure 6 Return loss vs. frequency curve of proposed antenna.

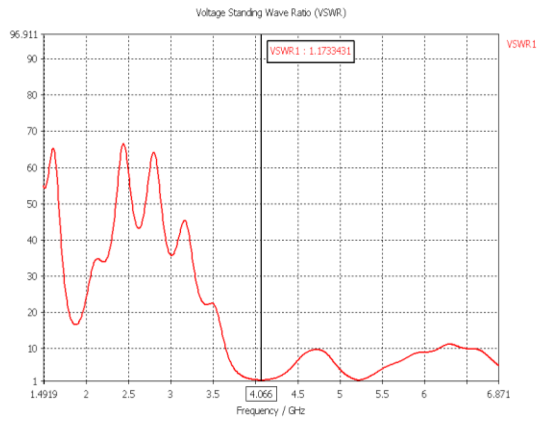

Figure 7(a) Voltage Standing Wave Ratio Curve for 4.066 GHz

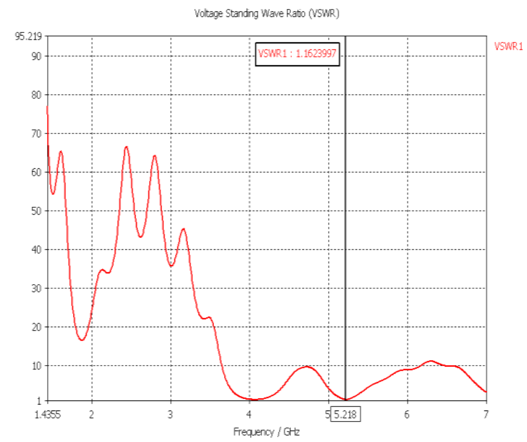

Figure 7(b) Voltage Standing Wave Ratio Curve for 5.218 GHz

The VSWR vs. frequency curve for the proposed antenna with Optimized parameters is shown below. The VSWR for the proposed antenna is 1.17 at 4.066 GHz and 1.16 at 5.218 GHZ that resemble with ideal value of VSWR.

Radiation pattern with principal E-plane and H-plane for the different frequencies are shown in figure.

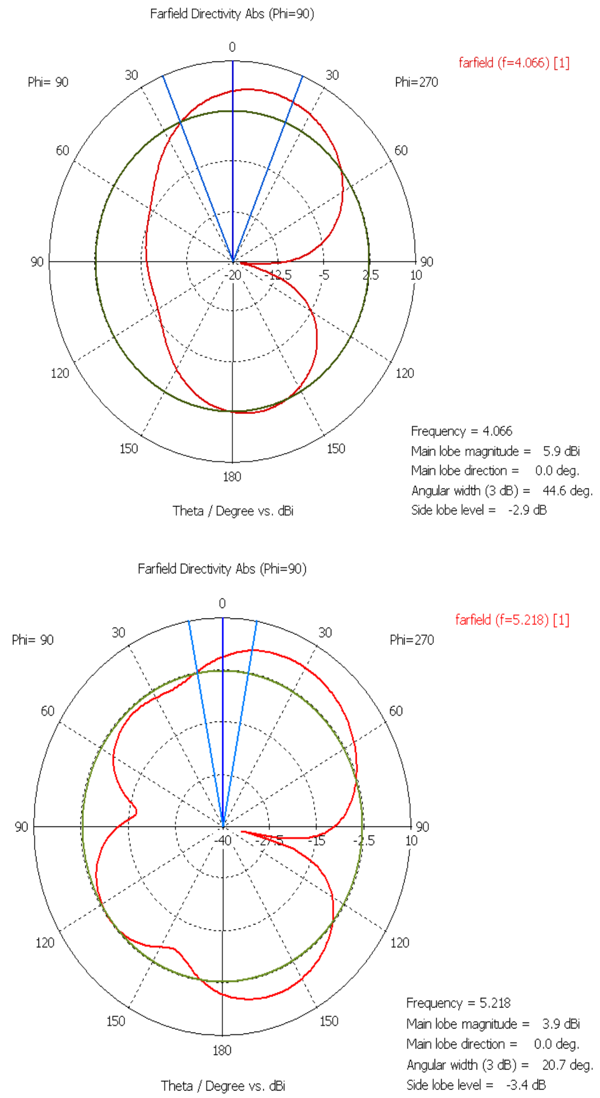

Figure 8 Radiation Pattern for frequency 4.066, 5.218 respectively

V. CONCLUSION

In this paper, a multiband microstrip antenna based on a fractal configuration with a modified ground integrating optimized slots, has been proposed and optimized for WiMAX and WLAN applications. The antenna exhibits good performances and good matching input impedance at, 4.066 and 5.218GHz. The antenna is low cost, compact, and exhibits moderate gain and stable radiation patterns which make it suitable for multiband wireless applications. This antenna has been validated into simulation by using CST Microwave studio. The different steps followed to design such antenna can be followed to match this structure to others operating frequency bands.

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