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Design of Fractal Microstrip Antenna with Defected Ground Structure for 5G Wireless Communications

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***Abstract*— The Microstrip antenna design is promising structure for advance wireless communication applications or in 5G. Fractal pattern is also very trending research area among antenna researchers. Various combination of fractal antenna designs using in various electronics applications. The frequency range of C band is 4-8GHz. Most of the 5G wireless communication application will lie in this range. This paper proposed single band microstrip fractal antenna with defected ground structure. These types of antennas can be used in 5G mobile communication applications.CST microwave studio software is used for design and simulation. Structure of proposed antenna is simple and compact in size of approx 32 X 32 X 1.64 mm3. The simulated results show that the frequency bandwidth covers 4-8GHz, at centre frequencies 5.4GHz for VSWR less than 2. The return loss values are -24.36 dB for 5.4GHz resonant frequency. The achieved bandwidth is 1064 MHz respectively.**

***Keywords*— Fractal, Microstrip, Antenna, Bandwidth, Return loss, VSWR.**

I. INTRODUCTION

Antenna designers are always looking to come up with new ideas to push the envelope for antennas, using a smaller volume while striving for every higher bandwidth and antenna gain. One proposed method of increasing bandwidth (or shrinking antenna size) is via the use of fractal geometry, which gives rise to fractal antennas. Fractals are those fun shapes that if you zoom in or zoom out, the structure is always the same.

They have wild properties, like having a finite area but infinite perimeter. They are often constructed via some sort of iterative mathematical rule that generates a fractal from a simple object step by step. The different wireless applications require distinct antenna, whereas, a multipurpose antenna is always a prime requirement of the market. Due to less weight, small size, ease of fabrication, low profile, multiband/wideband characteristics, Microstrip Patch Antenna (MPA) and Fractal Antennas are gaining huge popularity. Such fractal antennas are also referred to as multilevel and space filling curves, but the key aspect lies in their repetition of a motif over two or more scale sizes, or "iterations". For this reason, fractal antennas are very compact, multiband or wideband, and have useful applications in cellular telephone and microwave communications.

A fractal antenna's response differs markedly from traditional antenna designs, in that it is capable of operating with good-to-excellent performance at many different frequencies simultaneously. Normally standard antennas have to be "cut" for the frequency for which they are to be used and thus the standard antennas only work well at that frequency.

This makes the fractal antenna an excellent choice for wideband and multiband applications. In addition the fractal nature of the antenna shrinks its size, without the use of any components, such as inductors or capacitors. A fractal antenna is an antenna that uses a fractal, self-similar design to maximize the effective length, or increase the perimeter (on inside sections or the outer structure), of material that can receive or transmit electromagnetic radiation within a given total surface area or volume.

Such fractal antennas are also referred to as multilevel and space filling curves, but the key aspect lies in their repetition of a motif over two or more scale sizes,[1] or "iterations". For this reason, fractal antennas are very compact, multiband or wideband, and have useful applications in cellular telephone and microwave communications. A fractal antenna's response differs markedly from traditional antenna designs, in that it is capable of operating with good-to-excellent performance at many different frequencies simultaneously. Normally standard antennas have to be "cut" for the frequency for which they are to be used—and thus the standard antennas only work well at that frequency.

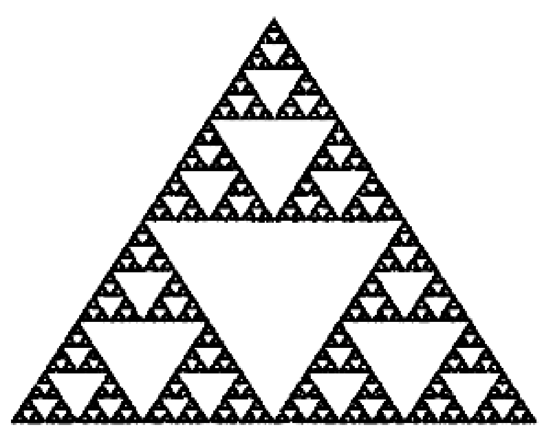

Figure 1: Fractal antenna

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A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale. There are many mathematical structures that are fractals; e.g. Sierpinski's gasket, Cantor's comb, von Koch's snowflake, the Mandelbrot set, the Lorenz attractor, et al. Fractals also describe many real-world objects, such as clouds, mountains, turbulence, and coastlines that do not correspond to simple geometric shapes.

II. Proposed Design And Methodology

The proposed research work is summarized is as follows-

- To design fractal micostrip patch antenna at C-band wireless frequency range.
- To enhance bandwidth and improve other performance parameters.
- To calculate parameters and compare with existing design results.

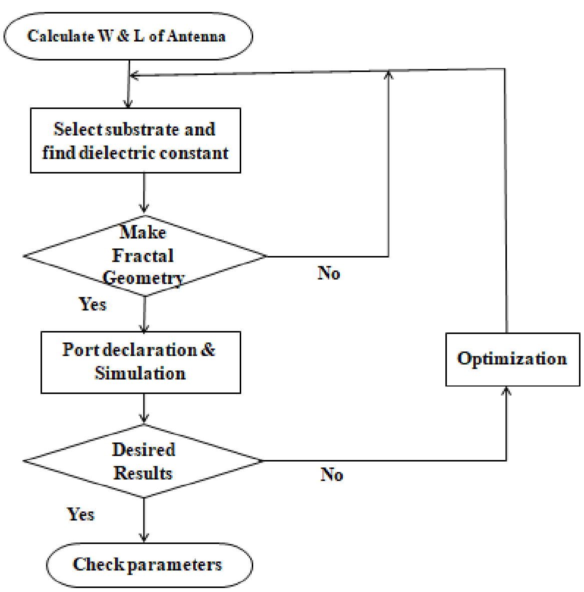

Figure 2: Flow Chart

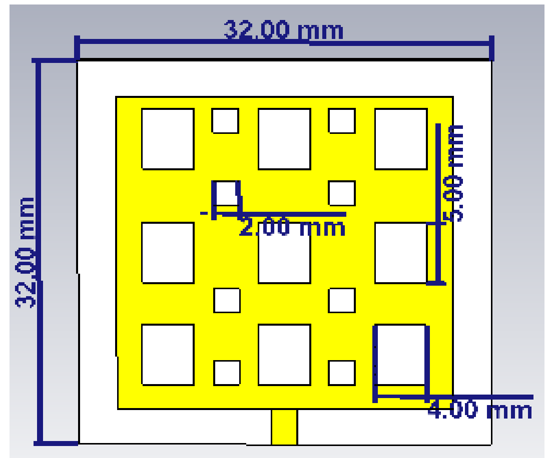

Figure 3: Dimension of proposed antenna

Figure 3 is showing dimension of different component of proposed antenna. This dimension is calculated based on standard formulas and optimization. Therefore the dimension of antenna is (LxWxH) 32 X 32 X 1.64 mm^3. The proposed antenna is based on fractal pattern so the dimension of first block is 4 X 5mm second block is 2 X 2 mm. The feed patch dimension is 4 X 3 mm. The substrate material which is using in proposed antenna is FR4 material.

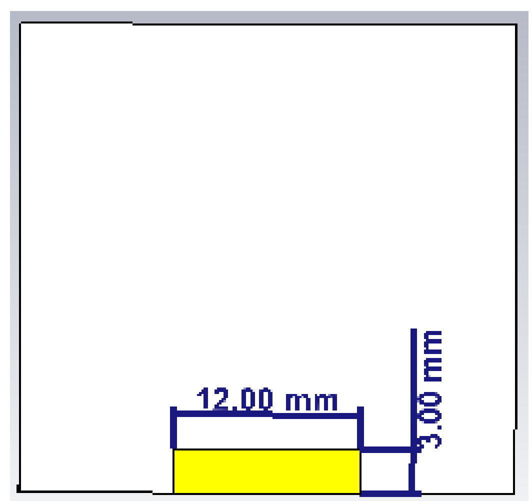

Figure 4: Bottom view of proposed antenna

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Figure 4 is showing bottom view of antenna, this is also known as ground structure. Proposed antenna is using defected ground structure.

III. SIMULATION RESULTS

The scattering parameters describe the electrical behavior of linear electrical networks when undergoing various steady state stimuli by electrical signals.S11 represents how much power is reflected from the antenna, and hence is known as the reflection coefficient or return loss. If S11=0 dB, then all the power is reflected from the antenna and nothing is radiated. Return loss is the difference, in dB, between forward and reflected power measured at any given point in an RF system and, like SWR, does not vary with the power level at which it is measured. Figure 5 shows the Return Loss (S_{11}) parameters for the proposed antenna.

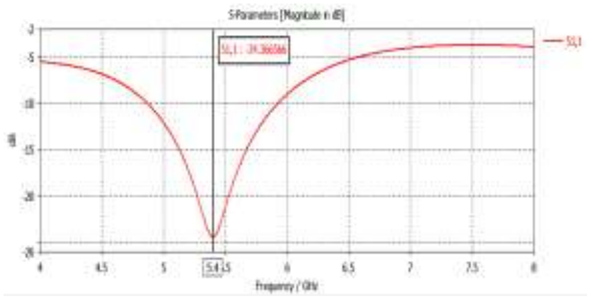

Figure 5: Return loss of band

The obtained value of S_{11} or return loss is -24.36 dB for 5.4 GHz resonant frequency, where antenna gives better performance.

The bandwidth of an antenna is defined as "the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard." For broadband antennas, the bandwidth is usually expressed as the ratio of the upper-to-lower frequencies of acceptable operation.

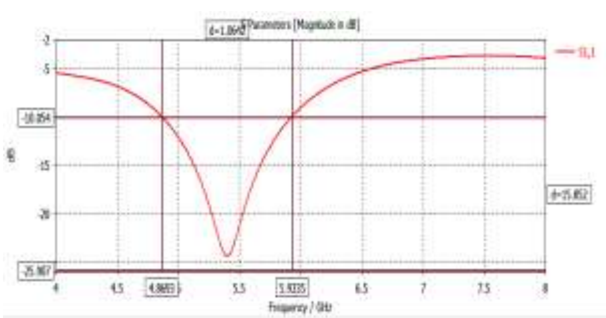

Figure 6: Bandwidth calculation of band

For broadband antennas, the bandwidth is expressed as a percentage of the frequency difference (upper minus lower) over the center frequency of the bandwidth. The bandwidth of proposed antenna is 1064 MHz (5.9335 GHz – 4.8639GHz) for optimize band.

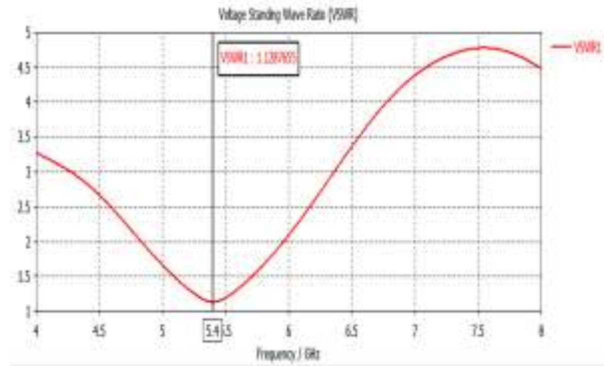

Figure 7: VSWR

VSWR must lie in the range of 1-2, which has been achieved for the frequencies 5.4 GHz. The value for VSWR is 1.128

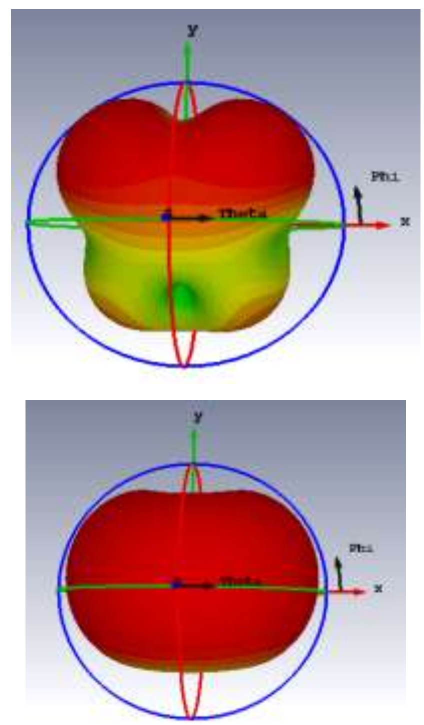

Figure 8: 3D Radiation pattern of proposed antenna

The radiation pattern of microstrip or patch antenna is broad. It has low radiation power and narrow frequency bandwidth.

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To have a greater directivity, an array is formed by using these patch antennas. In the field of antenna design the term radiation pattern (or antenna pattern or far-field pattern) refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. Minor lobes usually represent radiation in undesired directions, so in directional antennas a design goal is usually to reduce the minor lobes. Side lobes are normally the largest of the minor lobes. The level of minor lobes is usually expressed as a ratio of the power density in the lobe in question to that of the major lobe.

Table 1:
Simulation Results

Sr. No.	Parameter	Band-I
1	S11 or Return Loss	-24.36 dB
2	Band Width	1064 MHz
3	VSWR	1.128
4	Resonant Frequency	5.4 GHz
5	Efficiency	65%
6	Directivity	3.08 dBi
7	Gain	2.08 dBi
8	Y-Parameter (Admittance)	0.012

Table 2:
Result Comparison

Sr No.	Parameter	Previous work [1]	Present work
1	S11 or Return loss	-17.85 dB	-24.36 dB
2	Band Width	162.735 MHz	1064 MHz
3	VSWR	1.31	1.128
4	Resonant Frequency	5.8 GHz	5.4 GHz
5	Gain	1.92 dBi	3.025 dBi
6	Dimension	39.7 X 47 X 1.6 mm^3	32 X 32 X 1.64 mm^3

Table 2 showing comparison of proposed antenna results with previous design result in terms of bandwidth, return loss, resonant frequency and VSWR etc.

IV. Conclusion

A single band, fractal microstrip patch antenna is designed and simulated using CST simulation software. The simulation results are presented and discussed. Structure of proposed antenna is simple and compact in size of approx 32 X 32 X 1.64 mm3 the compact size of designed antenna makes it easy to be incorporated in small devices. Results show that the frequency bandwidth covers 4-8 GHz, at resonant frequencies 5.4 GHz, VSWR less than 2, and S11 -24.36dB. The final results satisfy all the parameters of proposed antenna. The designed antenna works efficiently under all conditions with low return loss and proper impedance matching.

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