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Design and Performance of Dual Band Microstrip Nano-Fractal Patch Antenna

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Now a day, Technologies for wireless communication are becoming more and more common and use a variety of frequencies. The need for antenna designs with the highly sought-after features of compact size, low profile, and multi-band has been increasing. High dielectric substrates and high electrical length. Fractal antenna can transmit and receive more than one frequency making it ideal for multiband use. Nano-Fractal antenna is efficient than the methods to make patch antennas smaller that are detailed below. By improving the antenna's design, etching periodic slow wave structures on the ground plane, adding inductive components to the patch's edges, and putting the slots inside the patch, the shorting posts procedures increase the electrical length of the antenna.

Keywords: Nano antenna, substrate, patch, optimization.

1. Introduction

This paper we introduce, we provide concept antennas with features that are advantageous to wireless communication receivers of the present day. Researchers' interest in low-profile systems has grown in recent years due to the growing need for portable systems. The antenna size plays a crucial role in creating communication systems with a low profile. Therefore, a variety of downsizing approaches have been proposed and implemented to Microstrip patch antennas, including the use of high dielectric substrates, resistive or reactive loading, and extending the electrical length of the antenna by optimizing its form and short-point technique.

Nano-Fractal forms have been shown to offer several advantages over conventional antenna types, including good electromagnetic energy radiation and favourable features. When fractal geometry is used to traditional antenna configurations, the antennas' total size is decreased by optimizing their form to enhance their electrical length. Fractal form antenna components offer a number of benefits since they share the space-filling and self-similar characteristics of fractal geometries. Decreased antenna size, multiband, and broad bandwidth stays the same. Fractal antennas are sometimes called space filling curves or multilayer curves, but what makes them unique is the way they repeat a theme over two or more scale levels, or "iterations." Because of this, fractal antennas are incredibly small, multiband or wideband, and have practical uses in 4G, cellular phones, wireless communications, and satellite communications.

2. Literature survey

Filling an antenna element with a substance with a high permittivity or dielectric constant is a typical method of reducing its size [8]. This dielectric "loading" raises the loaded element's effective electrical length by decreasing a wave's propagation velocity in that medium. Dielectric loading has a cost associated with it even if it can successfully lower an element's size. It is necessary to take into account the variations in electrical characteristics linked to a specific level of dielectric loading. Dielectric loading, in addition to increasing weight and expense, at minimum decreases an antenna's bandwidth and efficiency. The chosen dielectric's material qualities and the degree of reduction made will determine how much bandwidth and efficiency are lost. The reduction of bandwidth combined with manufacturing and material limitations can be a serious production issue for very narrow band components like Microstrip patches. Because of this, a broadband element that needs little or no dielectric loading may be advantageous.

The application of the fractal notion has increased the likelihood of creating antenna design objects. Mandelbrot was the one who first created the fractal geometry [9].Experimental research reveals that the patch's resonant frequency may be significantly reduced, and that this reduction occurs with increasing fractal form iteration order[1]. Because the fractal forms are Centro symmetric and self-similar, the emission patterns of the fractal-shaped antennas were preserved.[10]. There have been strong belief and evidences that multiband operating property of fractal antenna is a gift of its self-similar structure and or space filling propertyFig 1.

3. Theory of fractal antenna

Antenna Miniaturization Techniques

Literatures concerning the techniques of reducing the size of patch antennas include. By optimizing the form, etching periodic slow wave structures on the ground plane, filling the edges of the patch with inductive components [12], and inserting the slots into the patch [4], shorting posts methods can increase the electrical length of the antenna. However, as stated in Still others, these strategies can only reduce size by 65% at most. In contrast, a maximum size reduction of 75% was accomplished by combining the shorting posts technique with another downsizing technique, as [5]. However, the asymmetrical architecture of these tiny antennas significantly altered their emission patterns, and adding shorting posts made manufacture more challenging.

Nano Fractal Antenna

- ❖ It is the type of Microstrip-patch antenna used in multiband frequency application.
- ❖ An antenna that uses fractal geometry is called fractal antenna.
- ❖ It increases perimeter of material used in antenna by increasing the total electrical length of antenna in use.
- ❖ Iterations for multi-band application with multiple frequency.
- ❖ Cell-phone and microwave device.

Some key benefits of Nano Fractals antenna

3.3.1 Wide Bandwidth

Generally, the antennas which we use in the general-purpose use are of very small bandwidth. The antennas which are used in mobile phone support the frequencies in the MHz. These are generally the patch antennas which are cheaper but require a large amt of power.

When we try to use these antennas for the frequency in the GHz range, they tend to be inefficient and also tend to dissipate more power. In the application such as space communication where the use of power is very critical due to less availability of power the use of patch antenna is uneconomic.

Here we can use the fractal antenna which requires less power as compared to that of patch antenna of normal shape and the field strength obtained by this antenna is very high, this is the evident that the electrical length of fractal antenna is very large due to its fractal shape.

Thus, fractal antenna is perfectly suited for the high frequency& low power applications. The GHz frequencies which we working antenna is in the range of [3].

3.3.2 Multiband Frequency

The geometry of the antenna and shape of antenna gives working for multiple frequency. If we use general patch antenna which support only one frequency, though it would give a good directivity and gain but the main problem is when we have to work on more than one frequency this patch antenna of no use. In order to overcome this problem, we use fractal antenna.

Thus, by using fractal antenna we save both, hardware & power which would be wasted if we implemented same system using patch antenna for multiple frequency. The following example shows the multiband property of fractal antenna.

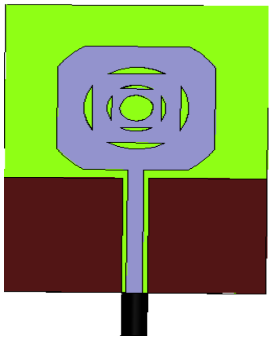


Figure 1 Multiband Property explanation of fractal Antenna

3.3.3 Small Size

It has very compact size. The main advantage of this antenna lies in the facts that it can be sticked on the surface where it is to be used saving more space and also look attractive due to self-similarity. The gain and efficiencies will depends on the size compared to antennas.

3.3.4 Space Filling Property

It uses the space available efficiently as same size of antenna can be used in the system working in multiple bands. It has very compact size along with excellent efficiencies and gains.

3.3.5 Mechanical Simplicity and Robustness

The characteristics of the antenna are obtained due to geometry of discrete components. We can stick it on any surface, which makes it useful for applications like space satellite application.

3.3.6 Self –Similar Property

The fractal antenna is very simple to design antenna as it is just implementation of basic shape taken over large no. of iteration giving it high efficiency, multiband nature and so onFig 2.

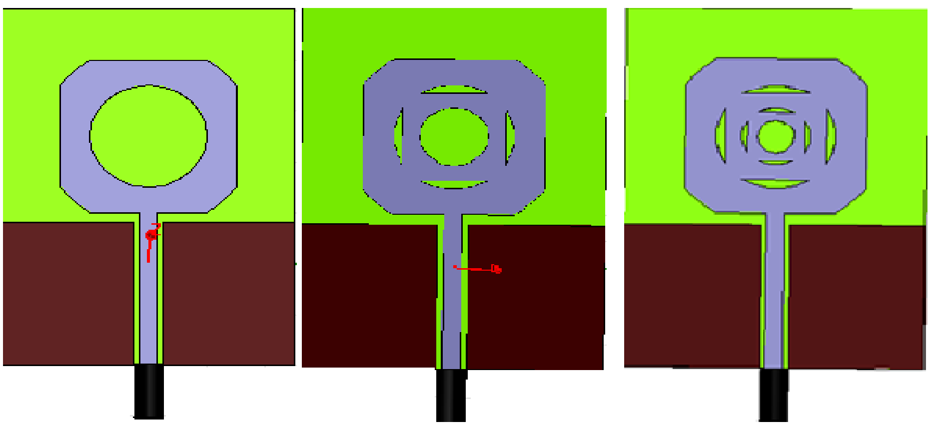


Figure 2 Self-similar property of Antenna

Above is the demonstration of self-similar property of antenna. Same basic rectangular Shape is repeated over each time Fig 2.

Methods of Fractal Antenna Design

There are two distinct ways to use the iteratively generated geometries.

1. Fractal- miniaturize antennas
2. Space filling ability
3. Scales of the geometry
4. Frequency bands
5. Fairly similar [8].

4. Design of fractal antenna

Two different type of fractal patch are designed on same substrate and with same dimensions having named as ANTENNA Detail description of each is given below.

4.1 Antenna

The radiating antenna is created using rectangular patch of 30mm x 30mm dimension as shown in Fig 1; on rectangular FR4 substrate of size 50 mm x 70 mm. Height= 1.53 mm and permittivity= 4.4. This basic structure (square) is then curved at edges by intersecting with a cylinder of radius 18mm, whose center is centeroid of square. Curved edge help in improvement of bandwidth operation. Central part of cylindrical shape of 10mm is etched out.

This is the basic or fundamental structure which is then scaled down to 56% of original size for preceding fractal stage. Three such fractals are united witch each other & feed line is connected to it having width is 3.1mm.

Coplanar ground on both side of feed with size 22.5 mm x 28 mm. Gap between ground & feed is 0.95mm. And ground to patch 2mm.

5. Simulated Results

The antenna design focuses on two bands i.e. S-band (2 GHz to4 GHz) & C -band (6 GHz to 8 GHz). With different bands the antenna is simulated & designed using Ansoft's HFSS 11.1v. HFSS stands for HFSS. The software is based on FEM method, in this technique large structures are converted into multiple fractal shape structure for ease of analysis. The results for fabricated antenna are found by FALCON ELECTRO-TEK PVT.LTD, Koparkhairne-Mumbai 304/1-3.2 GHz-VNA. The simulated & measured results are compared below

5.1 VSWR

For antenna to be in operating band, VSWR should be less than 2. As seen from following simulation results, we get 2 distinct bands in each Antenna type i.e. ANTENNA.

Table 1– VSWR range

Starting frequency in GHz	Ending frequency in GHz	frequency band in GHz
2.2571	4.00	2.2571
5.00	7.2	2.200

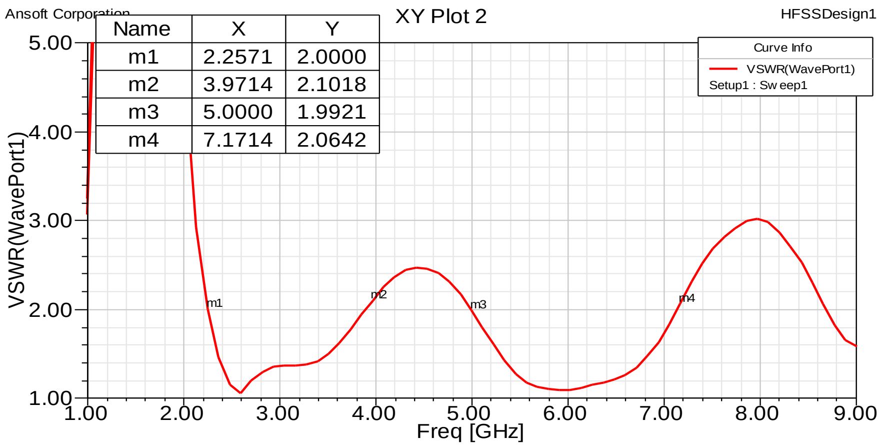


Figure 3 VSWR for Fractal antenna

5.2 Radiation Pattern

Antenna A is having Bi-directional Pattern as shown in fig 4. The pattern can be plotted as function of radiated energy, directivity, electric field intensity, magnetic field distribution, gain etc. for our project we have plotted Gain as a function of directive angles varying from 0 0 to 360 0. In both antennas i.e. ANTENNA as angle deviates from original plane; gain decreases. Which yields a bidirectional pattern like figure of Eight (8)

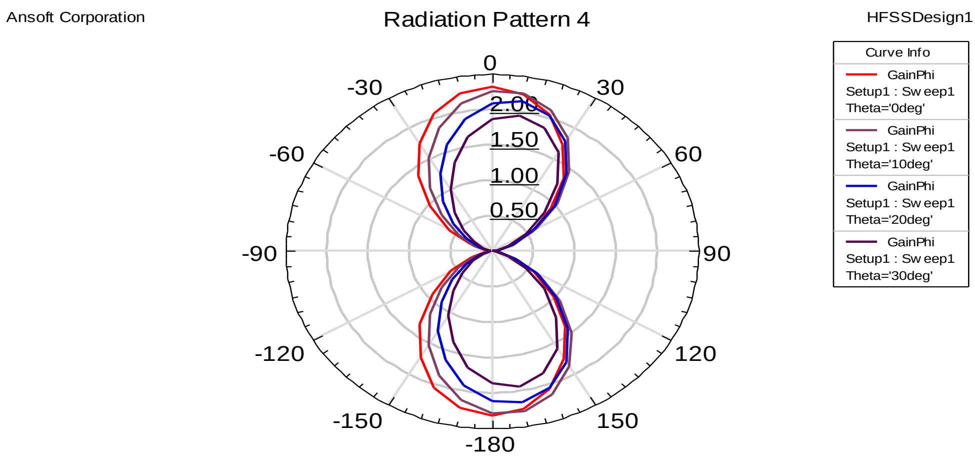


Figure 4 Radiation Pattern for Fractal antenna

5.3 Peak Gain

The Gain of the antenna found to be uniform around 6 dB for entire operating band of 2-4 GHz & uniform around 7.5 dB for entire operating band of 6-8 GHz (Antenna-A).It is observed that overall nature of graph is increasing from lower to higher band for all Antennas. Further graph is exponentially increasing for 0-2 GHz and is linearly increasing after 2GHz as shown in fig 5. The gain less than 0 indicate non- radiating frequencies.

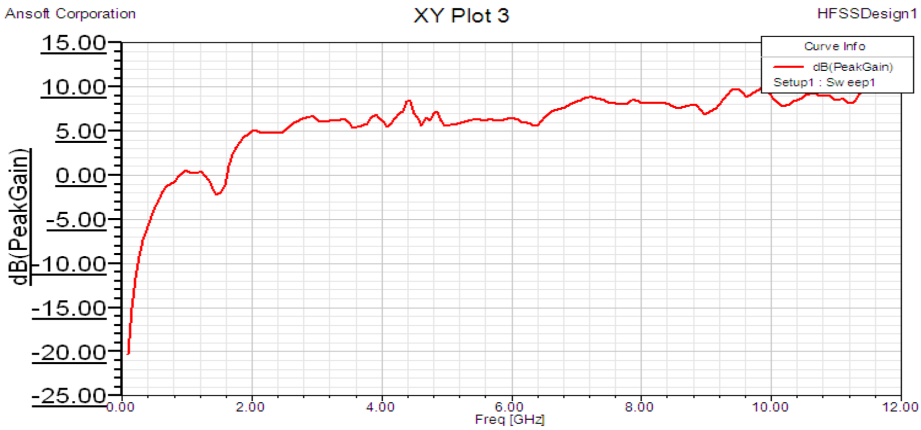


Figure 5 Peak gain for Fractal antenna

6. Experimental Results

Experimental results of antennas are taken at Falcon India Pvt. Ltd., Koparkhairne- Mumbai on-304/1-3.2GHz. VNA.

6.1 VSWR: As seen from following figure VSWR less than 2 at frequency 2.4GHz in Fig.6.

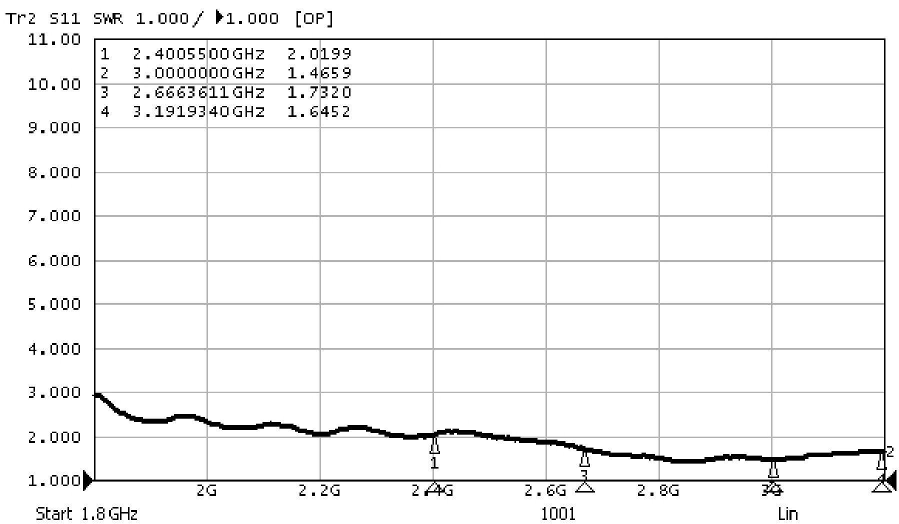


Figure 6 VSWR for Fractal antenna

6.2 Smith chart

Following figure shown that at 3.19GHz Impedance is 50Ω. in Fig.7.

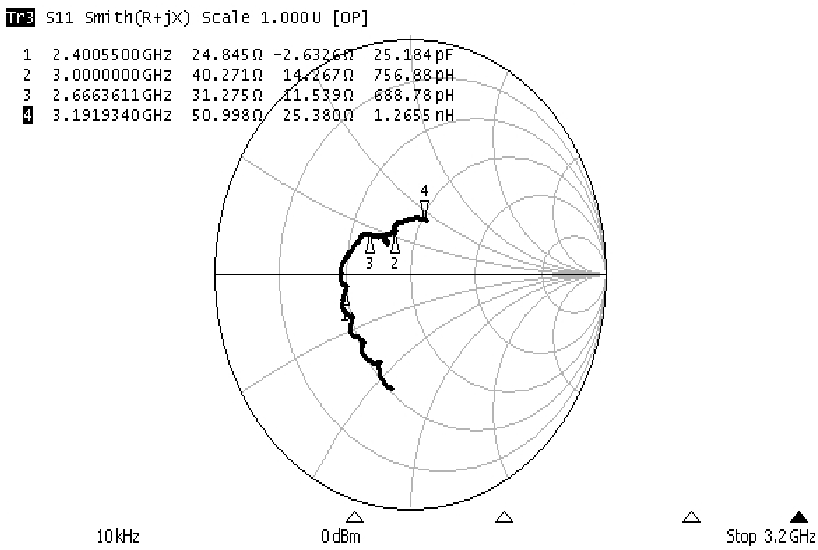
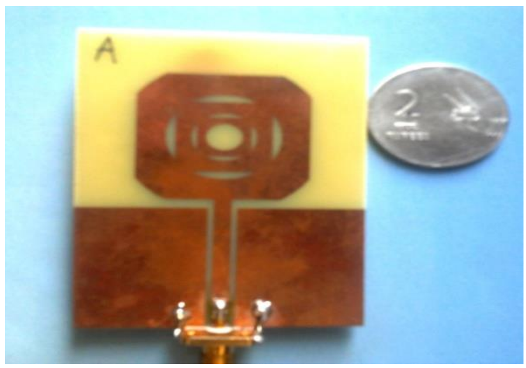


Figure 7 Smith chart for Fractal antenna

Testing antenna-A for Returner loss, VSWR & Smith chart with Hardware



Testing antenna-show Size of antenna with coin

6.3 Smith chart

Following figure shown that at 1.95GHz Impedance is 51Ω. Both the results are in almost same agreement, minor deviations occurred due to manual errors during fabrication, soldering and or testing of antenna.

7. Conclusion

The radiation performance of a Dual band frequency microstrip fractal patch antennas simulated by using HFSS v.11.1 simulation software and its performance is compared with measured result from FALCON ELECTRO-TEK PVT.LTD, Koparkhairne- Mumbai on-

304/1-3.2GHz. VNA. From the results we can conclude that multiband frequency nature is obtained by introducing fractals. Three different bands Combined together to yield two wide bands of 2 GHz each. VSWR-The antenna to be in operating band, VSWR should be less than 2. As seen from fig 3 &fig 6. From results we get distinct bands in each Antenna type i.e. ANTENNA. Smith Chart-As Smith Chart is concentrated around 50Ω (fig 7.) for required operating band, antenna will provide good impedance matching and will give good radiation efficiency as seen from fig 7.

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