



Design of Microstrip Patch Circular Monopole Fractal Antenna For Wireless Applications

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Abstract: The modern telecommunication system requires an antenna with wider bandwidth and smaller dimension than conventional antennas. This has initiated antenna research in various dimensions, one of which is used by a fractal shaped antenna element. Fractal is a concept being demanded for multi band operation. In this paper a circular shaped monopole fractal antenna using CoPlanar Waveguide feed (CPW) for wideband application has been proposed. The circular fractal patch and modified ground plane are employed to achieve the desired wideband characteristics. The antenna is optimized for a multi band operation. This antenna is simulated using Ansoft HFSS 11.0. For this design, low cost and readily available FR-4 substrate of relative permittivity of 4.8 and height 1mm has been used. The measured antenna parameters such as gain, radiation patterns and VSWR of the proposed antennas are found well for multi band operation.

Keywords: Microstrip Patch Antenna, Fractal Antenna, Co-Planar Waveguide Feed, HFSS, FR4 substrate.

I. INTRODUCTION

The use of fractal geometries has significantly impacted many areas of science and engineering; one of which is antennas. Antennas using some of these geometries for various telecommunication applications are already available commercially. The use of fractal geometries has been shown to improve several antenna features to varying extents. Microstrip patch antenna has attracted wide interest due to its important features, such as light weight, low profile, low cost, simple to manufacture and easy to integrate with RF devices. For reducing the size of antenna, fractal geometries have been introduced. A fractal is "a rough or fragmented geometric shape that can be split into parts, each of which is a reduced size copy of the whole.

Fractal has the following features

- It has a fine structure at arbitrarily small scales.
- It is too irregular to be easily described in traditional Euclidean geometric.
- It is self-similar.
- Simple and recursive.

For reducing the size of antenna, fractal geometries have been introduced in the design of antenna. Fractal geometries have two common properties: Self-similar property and Space filling property. The self-similarity property of certain fractals results in a multiband behavior. Using the self-similarity properties a fractal antenna can be designed to receive and transmit over a wide range of frequencies. While using space filling properties, a fractal

make reduced antenna size. Fractal antenna engineering is the field, which utilizes fractal geometries for antenna design. It has become one of the growing fields of antenna engineering due to its advantages over conventional antenna design. [1]

II. MICROSTRIP PATCH ANTENNA

A. Microstrip Patch Antenna

In recent years the area of microstrip antenna has seen many inventive works and is one of the most dynamic fields in communication field. For simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common. Among these the rectangular and circular patches are the most extensively used patches [2].

Although there are many variations on patch antenna design, the basic configuration is shown in Figure 1, where L is then length (relative to the feed point) and W is the width. In the simplest configuration, $L = W = \lambda_{eff}/2$, or an electrical on behalf wavelength, including the shortening effect of the dielectric constant (ϵ_{eff}) of the material between the patch and the conducting surface (substrate) below [1].

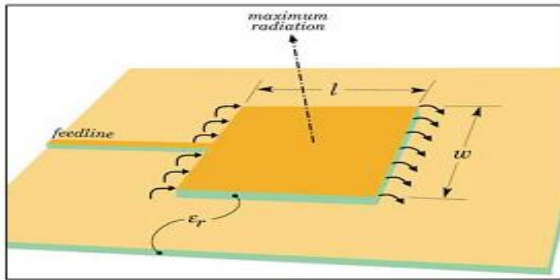


Fig. 1. Microstrip Patch Antenna

Microstrip patch antennas consist of very thin metallic strip (patch) placed on ground plane where the thickness of the metallic strip is restricted by $t \ll \lambda_0$ and the height is restricted by $0.0003\lambda_0 < h < 0.05\lambda_0$ and their dielectric constants are usually in the range of $2.2 < \epsilon_r < 12$ [1].

B. Microstrip Patch Antenna – Feeding Methods

Microstrip antennas are used not only as single element but also very popular in arrays. Main limitation of microstrip is that it radiate efficiently only over a narrow band of frequencies and they can't operate at the high power levels of waveguide, coaxial line, or even stripline [1]. This can be minimized with the help of various array configurations, feeding methods, dielectric materials and ground planes. Antenna arrays are used to scan the beam of an antenna system, to increase the directivity, gain and enhance various other functions which would be difficult with single element antenna.

There are several feeding techniques to excite an antenna. Inset Feed, Fed with a Quarter-Wavelength Transmission Line, Coaxial Cable or Probe Feed, Coupled (Indirect) Feed, Aperture Feed, CPW Feed.

Among all these feeding techniques the CPW-feed is widely used because of its wider bandwidth and many more advantages. There are two types of excitation techniques in CPW-feed mechanism. They are:

1. Coplanar Waveguide feed.
2. Grounded Coplanar Waveguide feed.

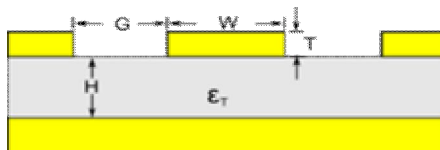


Fig. 2. Cross section of a coplanar Waveguide

where, W =width of the center conductor, H =height of the substrate. S =Slot width made between center conductor and ground plane.

III. FRACTAL ANTENNA

“A fractal is a shape made of parts similar to the whole in some way”. So, possibly the simplest way to define a fractal is as an object that appears self-similar under varying degrees of magnification, and in effect, possessing symmetry across scale, with each small part of the object replicating the structure of the whole [3].

For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and detail and self similarity makes it possible to design antennas with very wideband performances [1].

Fractals are a class of shapes which have not characteristic size. Each fractal is composed of multiple iterations of a single elementary shape. The iteration can continue infinitely, thus forming a shape within a finite boundary but of infinite length or area. Fractal has the following features

- It has a fine structure at arbitrarily small scales.
- It is too irregular to be easily described in traditional
- Euclidean geometric.
- It is self-similar.
- Simple and recursive.

For reducing the size of antenna, fractal geometries have been introduced in the design of antenna. Fractal geometries have two common properties: Self-similar property, Space filling property. The self-similarity property of certain fractals results in a multiband behaviour. Using the self-similarity properties a fractal antenna can be designed to receive and transmit over a wide range of frequencies. While using space filling properties, a fractal make reduce antenna size.

Features of fractal structure

- Fractal Antennas radically alter the traditional relationships between bandwidth, gain and size, permitting antennas that are more powerful, versatile and compact [4].
- Fractal Antennas produces fractal versions of all existing antenna types, including dipole, monopole, patch, conformal, biconical, spiral, helical and others, as well as compact variants of each only possible through fractal technology.
- Fractal Antenna's technology affords unique improvements to antenna arrays, increasing their

bandwidth, allowing multiband capabilities, decreasing size load and enabling optimum smart antenna technology.

- Increased bandwidth/multi-band and gain in addition to smaller size.
- The inherent qualities of fractals enable the production of high performance antennas that are typically 50 to 75 percent smaller than traditional ones.
- Additionally, fractal antennas are more reliable and lower cost than traditional antennas because antenna performance is attained through the geometry of the conductor, rather than with the accumulation of separate components or separate elements that inevitably increase complexity and potential points of failure and cost. The result is one antenna able to replace many at a high value offering to our customer.

IV. ANTENNA DESIGN

The geometry of the circular monopole fractal antenna is shown in Fig. 3. The fractal structure is used to obtain, "Wide Band Structure. The fractal structure is the self-similar design to maximize the length, or increase the perimeter of the material that can receive or transmit EM radiation within a given total surface. The CPW-fed antenna gives larger bandwidth of 6:1. The CPW-fed fractal antennas are widely used for multi-Band operation. MB (Multi-Band) antennas are intensively used for wireless communications such as transmitting and/or receiving EM energy in shorter durations and avoiding frequency and space dispersive.

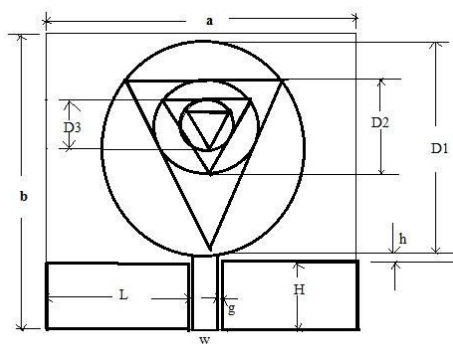


Fig. 3. Structure of the monopole antenna.

A CPW-fed circular disc monopole antenna for MB applications is designed, in which the current of proposed antenna is mainly distributed along the circumference of circular disc antenna. As a result, the current density is low in the middle area of

the circular disc antenna. The current will not be affected if the middle part of the circular disc antenna is cut, and the effective path of surface current will become longer. But the first resonant frequency will be decreased and the size of antenna will be reduced and also the bandwidth becomes smaller. The characteristics of these antennas are relevant to $D1$, L and H , h . It is also relevant to dielectric constant and thickness of substrate. Here, the substrate used is FR4 with thickness of 1mm, dielectric constant ϵ_r 4.5 and the electric tangent delta or loss tangent of 0.002 are used.

V. SIMULATION RESULTS AND DISCUSSIONS

The software used to simulate the circular monopole antenna is High frequency structural simulator software Ansoft HFSS for calculating various parameters. Fig. 4 shows the top view of coplanar waveguide fed circular monopole designed fractal antenna using Ansoft HFSS.

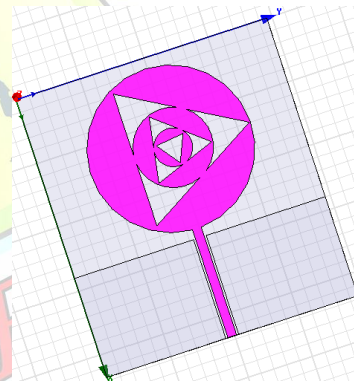


Fig. 4. Actual HFSS model (top view)

A. Gain Plot

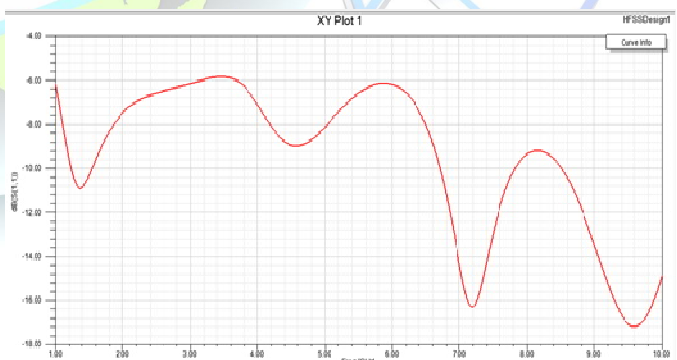


Fig. 5 Gain obtained for circular monopole fractal antenna

The gain of the antenna should be positive. In this paper the proposed antenna resonates at (4.62, 7.2 and 9.6) GHz with the gain of (8.9, 16.2 and 17) dB respectively. These results are shown in Fig.5.

B. VSWR Plot

It has been observed from the simulated results that, it gives the maximum resonance at frequencies 1.78GHz, 2.8 GHz as shown in Fig. 6.

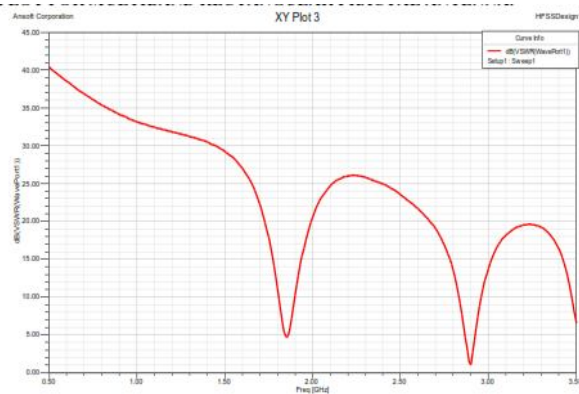


Fig 6 VSWR obtained for circular monopole fractal antenna

C. Radiation Pattern

The far field radiation pattern given in Fig. 7

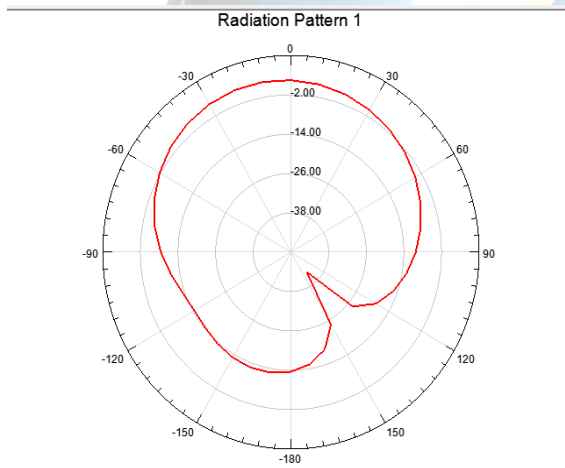


Fig. 7 Radiation pattern for circular monopole fractal antenna

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VI. CONCLUSION

A new compact circular monopole multi band antenna has been presented and implemented successfully by fractal technology. From the simulated results it is clear that the gain and radiation patterns and number of iteration increases multiband wireless applications. The CPW-fed Multi-Band circular Monopole fractal antenna provides good Multi-Band performance with a convenient smaller size. Therefore, the antenna is attractive for Multi-Band applications like WiMAX, mobile WiMAX applications.