Design of Fractal Circular Patch Microstrip Antenna for Multi-Band Applications

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Abstract— Microstrip or patch antennas are becoming increasingly useful because they can be reproduced directly onto a circuit board. Microstrip antennas are becoming very prevalent within the mobile handset market. Fractal antennas have move in the view of many as a very capable resolution. Fractal antennas size can be shriveled from two to four times with astounding good performance over Traditional antenna. Because FEAs (Fractal Element Antenna) are self-loading, no antenna regulation coils or capacitors are indispensable. Fractal antenna model is built, as is the case with conservative antenna perception, on classic electromagnetic theory. Fractal antenna idea uses a modern (fractal) geometry that is a ordinary extension of Euclidian geometry. Multi band Fractal circular microstrip patch antennas offers increase in gain and decrease in return loss at all multiband as well as the size of antenna becomes reduced.

Key words: Fractal Structure, Scattering Parameters, Circular polarization

I. INTRODUCTION

Microstrip antenna was aunpretentious antenna that involves of a radiated patch constituent, dielectric substrate and ground plane. The radiated patch and ground plane are thin layers of PEC. Each dielectric substrate has its own dielectric permittivity assessment. This permittivity influences the extent of the antenna. Microstrip antenna is a low contour antenna. They have numerous advantages like light in weight, small facet, cheap and easy to assimilate with other circuit make it preferred in a number of applications.

However, fractal antennas and its superset fractal electrodynamics is a state of undertakings for research activity. Although fractal geometry has been known to mathematics for a span, fractal antenna engineering research is a moderately very recent advance because significant calculating speed is required to widespread their design. In the research journals, we see information of vigorous research wrapper such diverse areas of Fractals use in antenna field and their compensations. Fractals are self-similar substances and hold structure at all measures. Fractal geometries have found an complicated place in science as a depiction of some of the inimitable geometrical features going on in nature. Fractal geometry was first revealed by Benoit Mandelbrot as a way to mathematically describe structures whose measurement cannot be limited to whole statistics.

It might be conceivable to determine structures that stretch us better enactment than any Euclidean geometry could afford. Fractals characterize a class of geometry with very distinctive properties that can be desirable for antenna originators. Fractals are space substantial delineations, meaning electrically large structures can be proficiently overflowing into small areas [1]. Since the electrical measurements play such an significant role in antenna design, this efficient filling can be used as a sustainable shrinking technique. Therefore, Fractals can be used in two ways to augment antenna schemes [2]. The first way is in the design of shrunken antenna elements. These can prime to antenna elements which are more detached for the end user.

The second way is to custom the self-similarity in the geometry to which are multiband. This would permit the machinist to integrate numerous aspects of their system into one antenna. Such antennas could be used to improve the functionality of modern wireless communication handsets such as cellular handsets. Now, many cellular handsets use quarter wavelength monopoles which are basically segments of radiating wires cut to are solute length. Although simple, they have tremendous radiation properties.

The concept of fractal antenna process is steeped in mathematics, but in its most basic form, it comes down to this: For more efficiency antenna has to work equally well at overall frequencies, it requisite gratified two criteria [3]:

1) It must be symmetrical around a point.
2) It must be self-similar, having the same basic exterior at every measure.

Fractal fulfills above situations that is why it shows wideband and multiple resonant frequencies behavior. The recompenses of fractal over conservative antennas are [4]:

1) Multiband concert is at non-harmonic frequencies.
2) Upgraded Impedance, EnrichedSWR(standing wave ratio) enactment on a reduced physical area when related to non-fractal Euclidean geometries.
3) Compacted resonant behaviour.
4) 0At higher frequencies the FEA is obviously broadband.
5) Polarization and phasing of FEAs also are conceivable.
6) In many cases, the use of fractal constituent antennas can streamline circuit design.
7) Reduced erection costs.
8) Improved consistency.
9) Often they do not necessitate any corresponding components to attain multiband or broadband performance.
10) Perturbation could be realistic to figure of fractal to brand it to resonate at transformed frequency.

II. FRACTAL CIRCULAR PATCH MICRO-STRIP ANTENNA

A. *Fractal's Definition*

A fractal is well-definedfrom the Latin fractus meaning broken, uneven, any of various irregular curves or shapes that repeat themselves at any scale on which they are examined.

B. Fractal Antenna

In wireless communication system and cumulative of other wireless application, extensive bandwidth, multiband and low contour antenna research in various directions, one of them is by using fractal shaped antenna elements. Conventionally, each antenna functions at single or dual frequency band, where different antenna is desired for different solicitation. Fractal formed antenna have already been demonstrated to have some exclusive characteristics that are link to the geometry of the fractal. Fractal geometry has exclusive geometrical features taking place in natural surroundings. It can be used to designate the branching of tree leaves and plants, roughness of shoreline and many more examples in nature. Fractal is defined by as set of F such that [5-7]:

1) F has a restricted structure with detail on subjectively small scales.
2) F is too asymmetrical to be relating by traditional geometry.
3) F is having some procedures of self- similarity.
4) F can be termed in a simple way, recursively.
5) Dimension of F is greater than its topological facet.

C. Fractal Antenna Elements

There ismuch welfare when we smear nature power (fractal) to develop numerous antenna elements. By spread over fractals to antenna element:

1) We can generate smaller dimension.
2) Attain resonance frequencies that are multiband.
3) May be enhanced for gain.
4) Accomplish wideband frequency band.

Most fractals have infinite difficulty and feature can be used to condense antenna size and low contour antenna. For most fractals, self-similarity conception can achieve multiple frequency band because dissimilar fragments of the antenna are alike to each other at altered scales. The combination of immeasurable complexity, design and self-similarity make it likely to design antennas with very wideband enactments[8].

D. Microstrip Antenna

The radiated patch and ground plane are thin layers of PEC or gold which is a good conductor. Each dielectric substrate has its own dielectric permittivity value. This permittivity effects the dimensions of the antenna. Microstrip antenna is a low contour antenna. They have several compensations like light in weight, small facet; cheap and easy to assimilate with other circuit make it selected in few applications.

Microstrip antenna consists radiating patch, substrate and ground plane. Bottom layer of dielectric is entirely sheltered with conductor that acts as a ground plane. The thickness of substrate layer can escalate the bandwidth and efficiency, but regrettably it will generate surface wave with low dissemination.

III. Design of Dual Band Fractal Circular Patch Microstrip Antenna for C-Band Application

A. Operating Frequency

The circular patch antenna with fractal harvests a dual band operation for the Multi-band application. Range of C- band is 2GHZ - 10GHz. The designed antenna is controls for triple band at 5.9GHz, 6.6GHz and 7.3GHz with increase in gain and bandwidth. Such type of antenna in range of C-band is useful in Telecommunication, Wi-Fi, Satellite communication, Radar, Commercial and Military application.

B. Antenna Geometry

The antenna structure based on a fractal geometry shown in Figure 1. This antenna has been designed on the substrate dielectric constant Ɛr= 2.3, thickness is 4mm with L-probe feeding. In the designing of a circular patch antenna, the following formula was executed to compute the radius of the circle.

$$a = K_{nm} \times c / 2 \times 3.14 \times f_{nm} \times \Delta r$$

Where,

f_{nm} = resonant frequency of the circular patch.

Δr= relative permittivity of the medium.

K_{nm} = mth zero of derivative of Bessels function of order n.

In our application we have considered the fundamental mode.

TM^{11} for which K valueis 1.84118. So,

$a = (1.84118 \times 3 \times 10^8)/(2 \times 3.14 \times 4 \times 10^9 \times$ square root(2.3))

= 14.4mm

The above equation is been used to define the all essential dimension of micro-strip patch antenna. The most important parameter required for the design of this antenna is the radius. The results are very delicate to modification in a radius of antenna.

A circular patch microstrip antenna of radius a = 16mm has been taken as base to fractal antenna. In the first iteration shown in figure1.Then the entire centre circle for each residual circle. The continuing small circle for this stage is sixteen. The entire centre circle for each remaining circle is mislaid. The infinite iterative erections are not possible due to the manufacture constraint.

1) First Iteration

For basic circular patch antenna the total area is (3.14*16*16), A0=803.84mm^2. After first iteration there total area become =722.16mm^2. Area for small circle is 81.6mm^2.

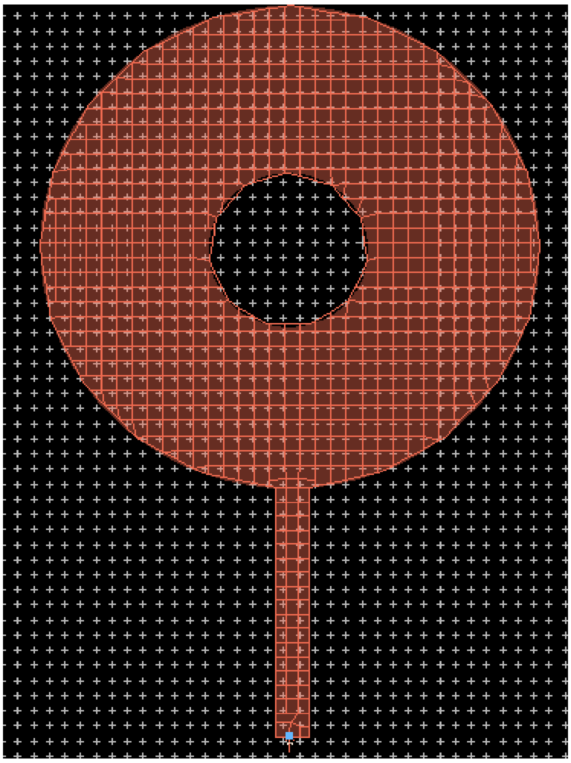

Fig. 1: Geometry for Circular patch Fractal antenna

The A1 is the balance factor for the small area after first iteration. The substrate material used is Roggers_RT_Duroid 5880 with the dielectric constant of 2.2.

2) S Parameter Plot for Return Loss vs. Frequency

S-parameters describe the input-output correlation between ports in an electrical system. A port can be loosely defined as any place where we can deliver voltage and current. Return loss is a measure of the effectiveness of power delivery from a transmission line to a load such as an antenna. The simulation of the design is carried out by the method of moment's technique using ADS software.

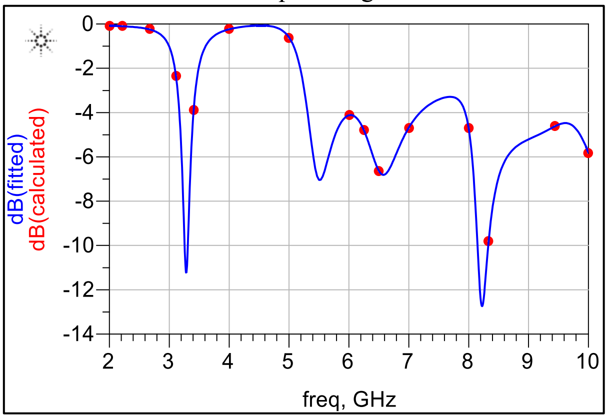

Fig. 2: Scattering parameter at different frequencies of patch

Figure 2 shows S parameter of circular patch fractal antennas at (3.2, 5.5, 6.6 & 8.2) GHz respectively. The return loss of the proposed microstrip patch antenna is (-11, -6, -7, -12) dBi. These resonant frequencies contribute the degree of the impedance bandwidth features of the antenna.

3) Second Iteration

The A2 is the scale factor for thefractional area after second iteration. After second iteration the total area become 716.44mm^2.

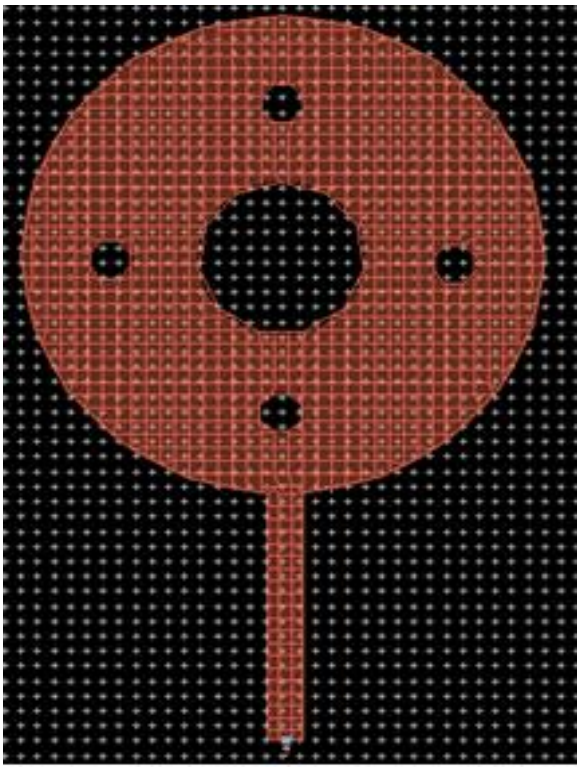

Fig. 3: Geometry for Circular patch Fractal antenna with first iteration

Area for one small circle is 5.1mm^2 and the total area for small circle that has been removed is5.72mm^2.The substrate material used is The A1 is the balance factor for the small area after first iteration. The substrate material used is Roggers_RT_Duroid 5880 with the dielectric constant of 4.6. with the dielectric constant of 4.6.

4) S Parameter Plot for Return Loss vs. Frequency:

Return loss is a measure of the effectiveness of power delivery from the microstrip antenna. The simulated antenna simulated resonant frequencies are (3.3, 5.5, 6.8 & 8.3) GHz.

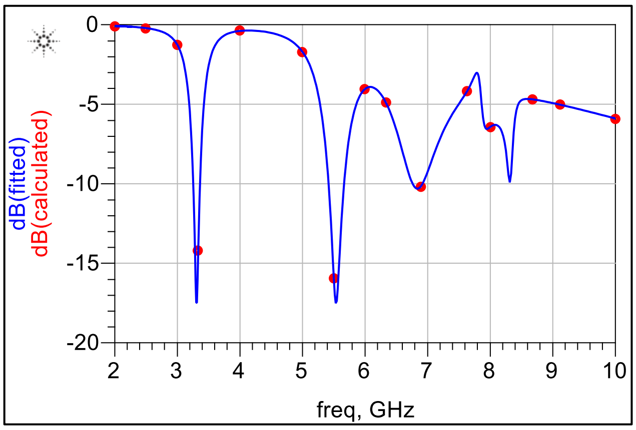

Fig. 4: Scattering parameter at different frequencies of Circular patch with second iteration

The return loss of the proposed Fractal antenna is(-17.4, -17.5, -10.2 &-9.9) dBi. Figure 4 shows S parameter of circular patch fractal antennas at Multi -bands as like as 3.3GHz, 5.5GHz, 6.6GHz and 8.3GHz.

IV. RESULT ANALYSIS

A. Circular Polarization

Circular polarization (CP) is frequently a result of orthogonally fed signal response. When two signals of equal amplitude but 90degree phase shifted the resulting wave is circularly polarized. Circular polarization can effect in Left hand circularly polarized (LHCP) where the wave is revolving anticlockwise, or Right hand circularly polarized (RHCP) which implies a round variation. The main improvement of overwhelming CP is that regardless of receiver alignment, it will always receive a component of the signal. This is due to the resulting wave having an pointed deviation.

The circular polarization plot gives that normalized electric field components consists of two orthogonal components , that are right electric field component(E_Right), and left electric field component, (E_Left).The circular polarization of fractal antenna with both first and second iteration is shown in Fig.5.

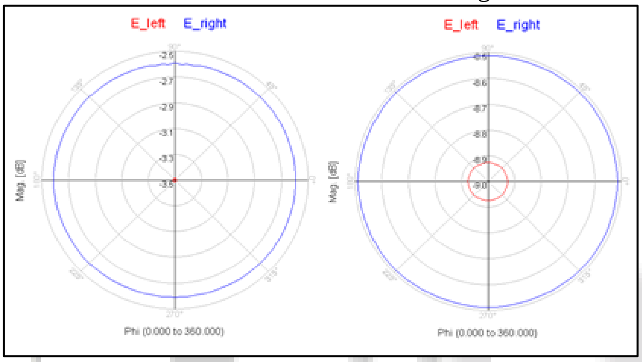

Fig. 5: Simulated circularly polarized H current distribution of circular patch antenna at first and second iterations

B. Gain and Directivity

Gain is not an extent which can be demarcated in terms of a physical quantity such as the Watt or the Ohm, but it is a dimensionless proportion. Gain is assumed in orientation to a normal antenna. The two maximum mutual reference antennas are the isotropic antenna and the resonant half-wave dipole antenna. The method of quantifying gain by comparing the antenna under test contrary to a known standard antenna, which has a regulated gain, is technically known as a gain transfer technique.

Directivity is the competence of an antenna to focus energy in a precise direction when transmitting, or to receive energy improved from a certain direction when receiving. In an immobile situation, it is possible to use the antenna directivity to deliberate the radiation beam in the sought afterdirection. Though in a vigorous system where the transceiver is notsecure, the antenna should discharge equally in entire directions, and this is known as an Omni-directional antenna.

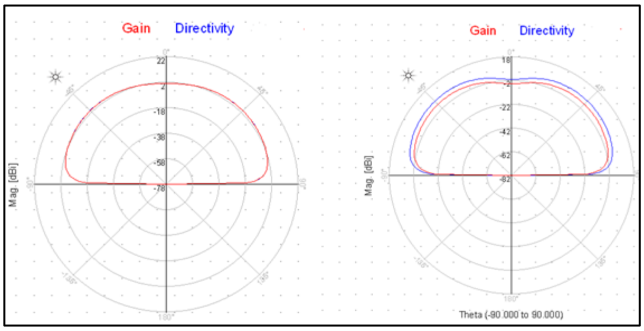

Fig. 6: Simulated Gain & Directivity of circular patch antenna at single and multiband.

Figure 6 shows simulated gain and directivity of circular patch fractal antennas at both single band and multiple band iterations. The obtained gain of first and second iteration circular patch fractal antenna becomes 6.4dBi and 3.2dBi. The directivity becomes 7.1 and 6.98.

C. Radiation Pattern

The input power is transformed into radiated power and surface wave power while a small portion is dissipated due to conductor and dielectric losses of the materials used. Surface waves are guided waves captured within the substrate and partially radiated and reflected back at the substrate edges. Radiation pattern shows a graphical representation of radiation properties of an antenna.

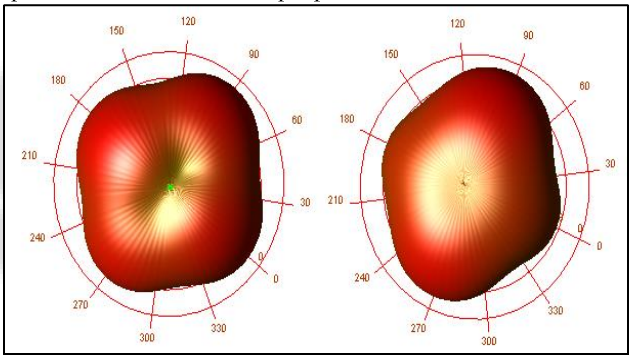

Fig. 7: Simulated Radiation Pattern of circular patch antenna at first and second iterations

The 3D representation of the radiation pattern of circular patch antenna is measured in both single and multi-bands which is illustrated in Fig.7. Asymmetric figure eight pattern is obtained for proposed microstrip slot antenna.

V. ANTENNA FABRICATION

Designing the antenna is only half the battle in building a better RF system. These antennas must still be fabricated, and equally advanced manufacturing processes must be used to achieve the level of precision and control necessary. Layout generation can be done in AutoCAD software for preparing the mask. Once the mask is printed on a transparent sheet, the patch can be fabricated using conventional photolithography process. The proposed antenna designed with the radius of 16 mm The A1 is the balance factor for the small area after first iteration. The substrate material used is Roggers_RT_Duroid 5880 with the dielectric constant of 2.2. Figure 4.1, shows that the before conversion of Gerber file of circular patch antenna with the thickness of the substrate 3 mm.

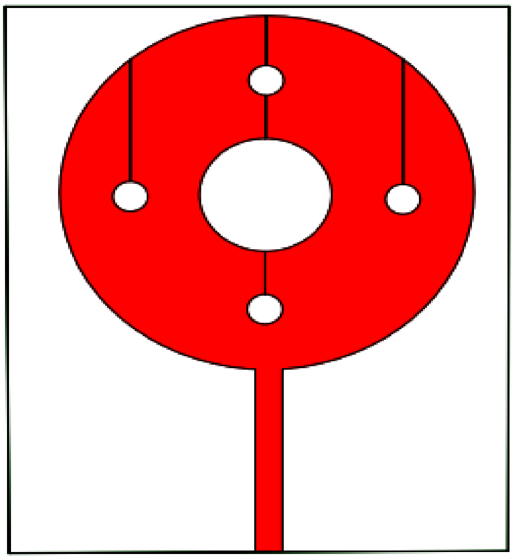

Fig. 8: Structure of proposed Fractal Circular Patch Microstrip Patch Antenna after Gerber file Generation

Figure 8, shows that the after conversion of Gerber files of circular patch antenna with the thickness of the substrate 3 mm.

The resistive layer in the above structure can be shown as the border of the circular patch antenna. This structure can be connected using connector to the network analyzer and the parameters of the antenna can be measured.

VI. CONCLUSION

The antenna can operate at 3.3GHz, 5.5GHz, 6.8GHz and 8.3GHz for triple band fractal antenna. The antenna offers increase in bandwidth and gain at all multiband as well as the size of antenna gets reduced. Further increase the bandwidth of a circular patch micro-strip antenna, a multilayer can be done. The obtained gain of first and second iteration circular patch fractal antenna becomes 6.4dBi and 3.2dBi. The directivity becomes 7.1 and 6.98. The polarization of this type of antenna can be examined by varying the feed position.

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