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Fractal Antenna for Wireless Applications: A Review

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Abstract

In the recent technological advancement, the modern wireless communication systems play an important role. The necessary part of this device is an antenna, which is required to provide wide bandwidth, high gain, compact size, high performance, supports multiple frequencies and satisfies various requirements of the system for both commercial and military applications. The miniaturized shape of antenna is the latest among all which is known as Microstrip patch antennas (MPAs). The MPAs are fully capable in attaining these requirements. Moreover, MPA is one of the most useful antenna for modern wireless communication because of its multiband characteristics, reduced size and shape, easy to manufacture, simple to build on PCB board and easy to fabricate. The fractal geometric shape of MPA is very popular to develop a miniaturized, multiband or wideband antenna with high gain and low profile for modern wireless communication services and applications. In this paper the feeding techniques of microstrip antenna and their advantages and disadvantages are discuss in detail. This paper also includes the application of microstrip fractal antenna and their geometries. This work also presents the identification of multiband and wide band Fractal antenna which is used for applications like Wi-Max, WSN, cognitive radio network, Wi-Fi, Li-Fi, Bluetooth, cellular, satellite communication, internet of things and optical fiber network depending on the range of operating frequencies.

Keywords: Compact Size, Fractal Antenna, MPA, Multiband and Wideband

Introduction

The antenna is a metallic device which used to radiate or receives electromagnetic waves (EMW) from one source to destination in communication systems. Antennas are any basic electric system components which acts as a connecting links between receiver and free space or transmitter and free space [1-2]. It is normally used for various applications such as radar, command and control systems, satellite and mobile communication, radio and television broadcasting and direct broadcast service. Recently, most modern wireless communication systems required an antenna that have compact size, high gain, high performance, wide bandwidth and operating in multiple bands that should be smaller dimension design and low cost [3-4].

Bob Munson in 1972 developed Microstrip parch antenna. Now a days microstrip patch antennas (MPA) are commonly the most widely used types of antennas because of its several advantages like low volume, light weight, low cost, easy to manufacture, easy to install to the rigid surface and simple to build on PCB board. However, microstrip patch antennas have some drawbacks such as narrow bandwidth with low efficiency, large losses in feeds, low power gain and low power handling [5-6].

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Fractal antennas have also been developed to improve the multiband capability of microstrip antennas and used to represent a class of unique properties of geometry. The fractal word was originally defined in the year 1975 by the French mathematician Benoit Mandelbrot to describe recursively generated self-similar geometric shapes. This term is derived from the Latin word "fractus" meaning: to break or irregular fragments or any of various irregular shape or curves that repeat themselves at any scale they are observed [7-8]. The fractal geometries structures can be defined as a rough or fragmented shapes that possess an inherent self-similarity which is created from the complex structures occur in nature [2], [8].

Microstrippatch Antenna

The variety of microstrip antenna is regularly used in the communication and electronics systems, microstrip patch antennas (MPA) are the most common in these systems. A simple microstrip patches antennas consists a pair of parallel conducting layers which separated by dielectric substrate. The radiating patch is placed on the top of a dielectric substrate and the ground plane placed on the bottom surface of a dielectric substrate. The patch and ground plane are normally made of the same conducting material like copper, thin gold or nickel. Here, commonly used any geometrical shapes for radiating patch such as rectangular, circular, disk, ring and ellipse but, circular and rectangular shapes are the most usually used [9-10].

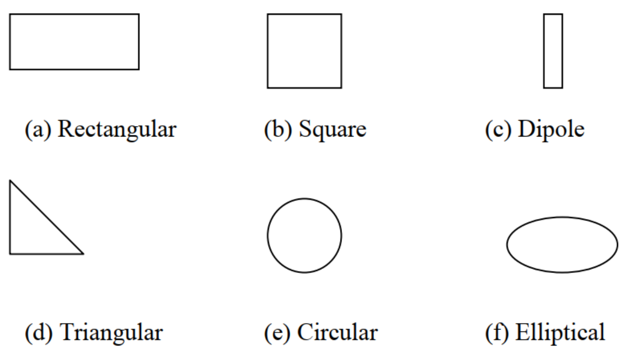

Figure1: Representative shapes of MPA elements

The radiating patch and the feeding lines are photo etched on the top of the dielectric substrate. One of the important role to design acceptable an antenna, choice the appropriate types of the dielectric substratematerial and its thickness.

Selectionofmaterialfordielectricsubstratedependsonitsrelativepermittivity with $2.2 \leq \varepsilon r \leq 12$.The antenna design requirement of the dielectricsubstrate is made a material like Teflon, Polythene, Glass, FR4 epoxy, Rogers RT duroid,Polyester , etc.FR4 epoxy is the most commonly used dielectric substrate material since it has low cost and easily available in the markets [2].

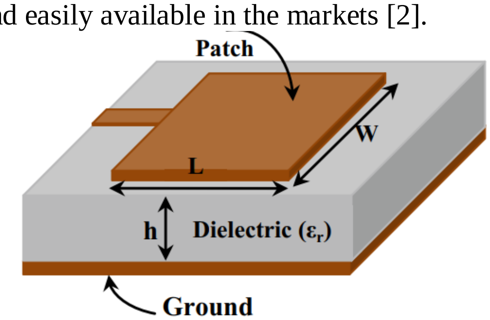

Figure 1:Basicconfigurationrectangularpatch

Several factors or parameters are used to determine the performance of the antenna. The physical and electrical characteristics of an antenna can be specify by the these parameters such as gain, directivity, voltage standing wave ratio, radiation pattern, polarization, reflection coefficient, bandwidth and input impedance [11-12]. The first task to design microstrip patch antenna is calculate the dimension of antenna by selecting an appropriate resonance frequency and dielectric substrate. The length of patch (L_p), the width of patch (W_p), the width of ground (W_g), the length ofground (L_g) and the height of dielectric substrate (h) are the parametersrequired to determine the dimension of the antenna. The proper feeding location on the antenna also a matter of concern to get the better impedance matching [6]. There three basics parameters to design microstrip patch antenna, such as operating frequency, dielectric substrate and height of dielectric substrate [13-14].

a. **Dielectric substrate (ε_r):-** To design microstrip antenna the dielectric substrate plays very important roles. Selection of the dielectric material is depends on its dielectric constant. A dielectric substrate having a high dielectric constant has been selected because the dimensions of the antenna is smaller due to higher dielectric constant.

b. **Operating frequency (fo):-**The resonance frequency ranges are one of the most commonly factor used to design microstrip antennas. To identify the desired antenna for wireless commination systems, must be choose the appropriate frequency range to calculate the length and the width the designed antenna.

c. **Height of substrate**:- The main aim design of a microstrip antenna is reduced the size, to attained the goal without changing other parameters of the antenna like gain, efficiency and bandwidth must be set the thickness of the dielectric substrate. The width and the length of design antenna is directly depends on the height of the dielectric substrate.

Table 1: Substrate materials with its dielectric constant and also, height and width of the patch at 2.4 GHz.

No	Dielectric Constant	Types of Materials	Patch Height	Patch Width
1	2.1	Teflon	56.71	69.93
2	3.2	Taconic TLC	46.14	57.51
3	4.4	FR4_epoxy	39.83	50.07
4	5.7	Mica	34.69	45.53
5	6.15	Rogers R03006	33.40	44.07
6	7	Silicon nitrate	31.32	41.67
7	8.3	Marble	28.78	38.64
8	9.2	Alumina 92pct	27.33	36.90
9	10	Sapphire	26.21	35.53
10	11.9	Silicon	24.04	32.81
11	12.9	Gallium arsenide	23.08	31.61
12	16.9	Diamond	20.14	27.86

Feeding Techniques

The excitation technique or Feeding technique is one of an important in design parameter of the antenna. This techniques is used to feed radiate electromagnetic energy by direct or indirect to microstrip antenna. It can be operating at full power transmission and also influences the antenna efficiency, the polarization characteristics and the input impedance of antenna. There are two basic categories of feeding techniques such as contacting and non-contacting. In the contacting techniques, RF power is fed directly to the radiating patch using a connecting element. On the other hand in non-contacting methods, electromagnetic field coupling done to executed the transmission power between the microstrip line and the radiating patch [9]. There are five common feeding techniques that can be used such as, microstrip line, proximity coupling, aperture coupling and coplanar waveguide feed [10].

a. Aperture coupled feeding

Aperture coupled feed is non-contacting feed techniques and consists two different substrate, which is the ground plane used to separates the microstrip line and the feeding line. Energy is coupled to the radiating patch from the microstrip feedline on the bottom side of lower substrate through a slot or an aperture on the ground plane. This arrangements are independent from the optimization of the radiating element and the feed mechanism element. Typically for the top substrate a thick low dielectric constant material is used and for the bottom substrate a high dielectric material is used. Typically a high dielectric material is used for the bottom substrate, and thick low dielectric constant material for the top substrate. To isolates the feed from the radiating element and reduces interferences of the spurious radiation for polarization purity and pattern formation kept the ground plane in the middle of the two dielectric substrate. Optimize of the design controlling by the feed line width, and substrate parameters, slot position and slot size [9-10].

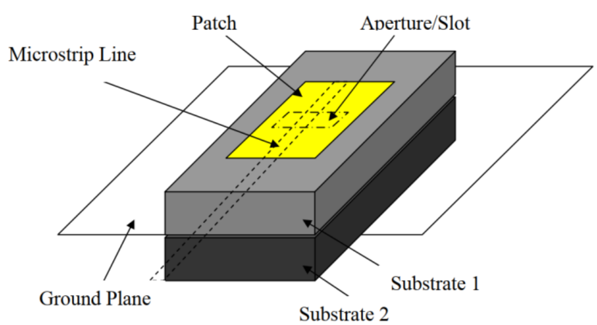

Figure 3: Aperture coupling feed microstrip antenna

Advantages of aperture coupling techniques are has low cross polarization, moderate spurious radiation and easy to model. However, it is most difficult to fabricate and has narrowband width[10].

b. Proximity Coupled Feeding

The Proximity coupled feed techniques is also called electromagnetic coupled feed. It is non-contacting feed techniques and consists two dielectric substrate. The feeding line used to separates the two substrates and the ground plane presents on the bottom of the substrate while the radiating patch is on top of the upper substrate. This techniques can be done by two methods, the first method is by placing the feedline and the radiated patch at different layers. The next method is creating a small gap between the feedline and the radiated patch on the same substrate layer [9-10].

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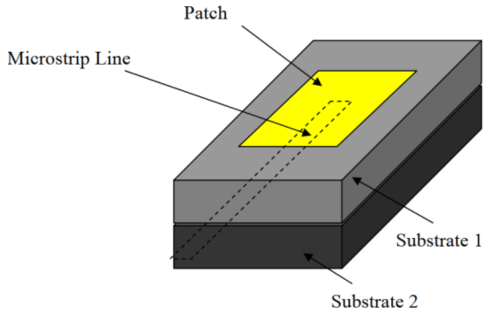

Figure 4:Proximitycouplingfeedmicrostripantenna

The major advantage of Proximity coupled feed techniques are has low spurious radiation, provides very high bandwidth (13%) and easy to model. However, the main disadvantage of this feed techniques are the overall thickness of the microstrip patch antenna increases, difficult to fabricate and need more cost [9-10].

c. Microstripline feeding

The microstrip line feeding is directly connected a conducting strip with the radiating patch element and the simplest feeding techniques than the others [9]. The advantages of this feeding techniques are simple to model, easy to fabricate, and easy to match by controlling the inset cut position in the patch. However the drawback of this method is that as substrate thickness increases, spurious feed radiation and surface wave also increases which limit the bandwidth [10].

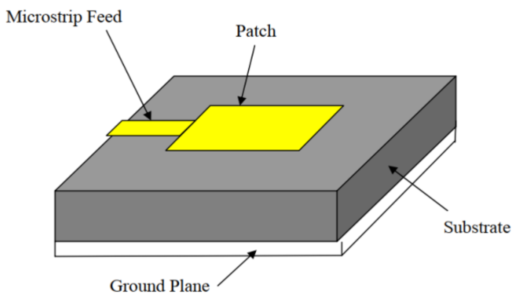

Figure 5:Microstrip transmission linefeed

d. The coaxial probe feeding

The coaxial probe feeding is a technique where widely used for feeding microstrip patch antennas. In this techniques, the inner conductor of the coaxial cable is attached to the radiating patch of the antenna and the outer conductor of the coaxial cable is attached to ground plane of the antenna. The advantages of coaxial probe feeding techniques are easy to match, low spurious radiation and easy of fabrication. But the limitation of this techniques are difficult to model in a thicker substrate and has narrow bandwidth [9-10].

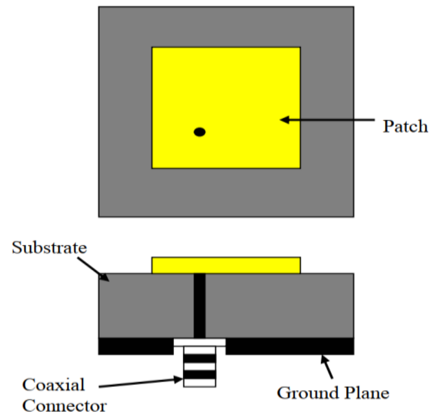

Figure 6:Coaxialprobefeedpatchantenna

e. The coplanar waveguide (CPW)feed

A coplanar waveguide feeding contains the ground pane and a metallic strip place on the top of a dielectric substrate which is slab with two narrow strip on the same surface. All of the conductors are on the same side of the substrate and the line is uniplanar in construction. The proximity coupled and aperture coupled feeding experience alignment problem between the feed line and the slot in wideband techniques. However, this problems is not occur in a coplanar waveguide feeding technique due to having etched both of them on the same side of the substrate. Now a day a coplanar waveguide feeding technique become more and more attractive, in case of several attractive characteristics like wider bandwidth, good impedance matching and easier integration with active devices or monolithic microwave integrated circuits. The alignment problem desired in other wideband feeding techniques like proximity feed and aperture coupled eliminated by etching the slot and the feed line on the same side of the substrate [15].

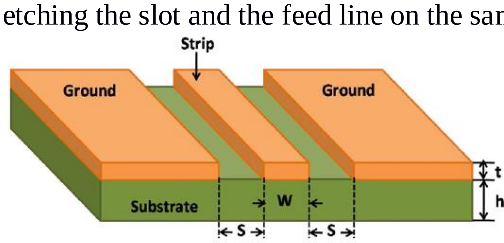

Figure 7: Co-planar Waveguide feeding

Fractal Geometries

Nathan Cohen during the year 1988, constructed the first fractal antenna which is designed by using simple fractal geometries. Fractal geometries are widely used in many area such as engineering and science. The fractals geometrics have unique features that can be constructed from the complex structures found in nature. Antennas design with fractal geometries are very useful due to their multiband nature, compact size, low weight, and easy manufacturing [4]. The fractal geometries are used to improve performance of antenna in terms of antenna size reduction and multiband characteristic with increase the effective length of the fractal antennas [16].

There are two basic unique properties of the fractal geometries are space filling and self-similarity. Self-similar property, the design fractal antenna to achieve multiband frequencies can be similar to each other

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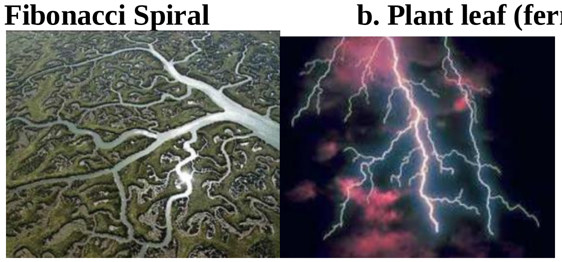
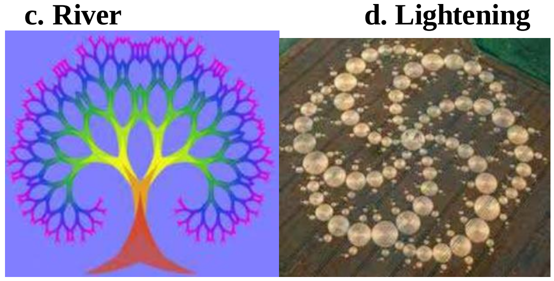
when viewed at different scales. Since the overall global shape is similar to the subparts of the designed fractal antenna. Space filling property is another important property of the fractal geometries that is used to reduce the size an antenna by increasing the electrical length into a compact physical volume [8], [17]. Fractals are basically classified as either deterministic or random. Deterministic fractals on the other hand, are usually generated by through rotated copies and scales down of itself such as Hilbert curves, Koch curves, Sierpinski gasket, Sierpinski carpet, minkowski curve, cantor set and etc. Random fractal sallow simulation of naturally occurring phenomena, as they contain elements of randomness such as river, plant leaf or tree, clouds, broccoli, vegetable, galaxies, lightening, earthquakes, Fibonacci spiral and coastline [3], [8], [14].

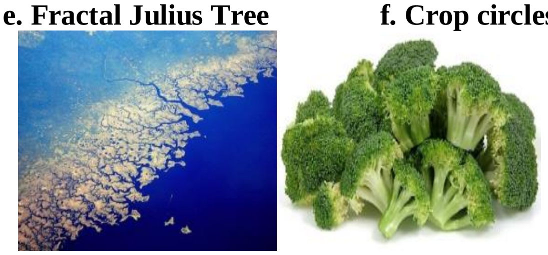
a. Fibonacci Spiral **b. Plant leaf (fern)**



c. River **d. Lightening**



e. Fractal Julius Tree **f. Crop circles**



g. Coastline **h. Broccoli**

Figure 8: Fractal shapes excising in nature

These fractal geometries are categorized into different types, such as Sierpinski structure, Tree structure, H-Tree, Pythagorean Tree Fractal, Koch Structure, Hilbert Curve and Minkowski Geometry.

a. Sierpinski structure

This structure was invented by Polish mathematician Waclaw Sierpinski in 1915. There are two basic types of Sierpinski structure:

1. Sierpinski Gasket

Sierpinski gasket, also known as Sierpinski triangle geometry which is a fractal geometry that can be most commonly used for antenna applications. The starting shape sierpinski gasket is created from equilateral triangle. The first step is divided equilateral triangle into four equal smaller equilateral triangles with each one being half of the size of the original triangle then remove the central triangle. After remove the central triangle, three equal sized triangles remain on the structure which is called first iteration. So the first iteration is self-similar structure with each shape is exactly the same shape as the original triangle however, the size reduced by two factor. The same to the first iteration each reaming triangle is replaced by three small size triangles to attain the second iteration and repeated the same process several times in order to obtain next iterations [7], [18].

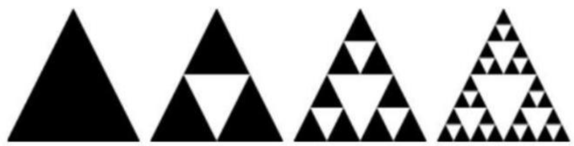


Figure 9: Iterations of Sierpinski gasket structures.

2. Sierpinski Carpet

The Sierpinski carpet geometry can be designed similar to sierpinski gasket geometry except it uses square or rectangle in place of triangle. The base shape of the Sierpinski carpet is a square or rectangles in the zero iteration. In order to obtain first iteration divided the square or rectangle into nine smaller equal squares or rectangles then remove the central square or rectangle from original structure. In the first iteration eight squares or rectangles are remaining and every square or rectangle is divided into nine smaller squares or rectangles then remove central square or rectangle from each. Repeated several times the same procedure in order to get next order iterations [18].

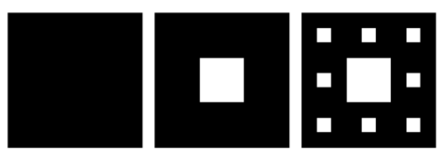


Figure 10: Iterations of sirpinski carpet structures.

b. The Tree structure

The tree structure has the shape of a tree. There are several types of each structure. In order to get the next iteration generate the same shape with a reduction factor [19].

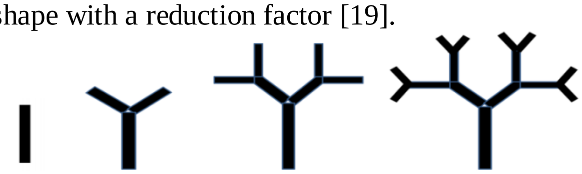


Figure11: Iterations of tree structure.

c. The H-Tree

The concept based on the H-Tree geometry is the same as tree structure except the initiator uses H letter. To generate the next iteration make four copies to each of the preceding iteration with reduction factor H [19]

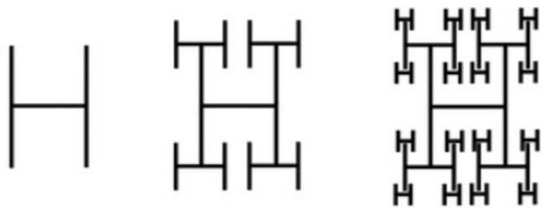


Figure 12:Iterations of H-Tree structure.

d. Pythagorean Tree Fractal

The geometry of zero iteration start from rectangle or square in Pythagorean tree fractal. To generate the first iteration place two squares upon the main square with the corners coincide with the main square. In order to get next order iterations follow the same procedure accordingly [19].

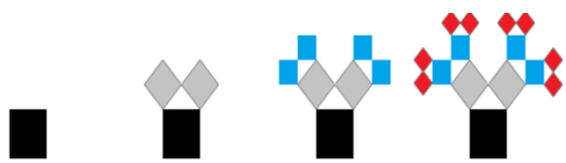


Figure 13: Pythagorean Tree Fractal

e. Koch Structure

Swedish mathematician Helge Von Koch was developed the Koch structure in 1906 even before the term "fractal" had been coined.

1. Koch curves

In 1998 the simplest Koch curve fractal antenna can be generated. The Koch curve antenna started from straight line then divided the line into three equal parts to make the first iteration. To obtain the next iteration bends the middle part of the straight line into the triangular shape with flare angle 60^0. For higher iteration of the fractal geometry take the same process can be reused [12-14], [17]].

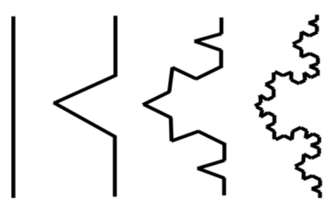


Figure 14: Iterations of Koch curve structures.

2. The Koch snowflake

The procedure to generate a Koch snowflake is the same as to create Koch curve except that the base is a triangle, which means that the procedure is repeated three times for every iteration [8], [11].

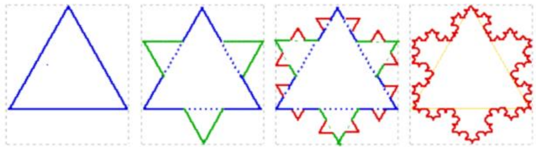


Figure 15: Iterations of Koch snowflake structures.

f. Hilbert Curve

The Hilbert curve was given in 1891 by David Hilbert who is a German mathematician. Due to the properties of fills the area it occupies, the Hilbert curve also called Space Filling Curve. The Hilbert curve is generated by placing the four replicas of the original iteration having different directions then using additional line segments joining these replicas. Use the same method to attain the next higher iteration. The curves of the geometry is simple because lines of the geometry do not intersect with each other and also easily can be drawn [2], [17].

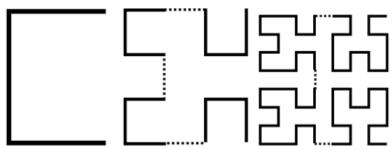


Figure 16: Iterations of the Hilbert curve.

g. Minkowski Geometry

Minkowski Geometry is being invented by a Jewish German Mathematician Hermann Minkowski in 1907. The geometric shape of Minkowski curve is designed by taking the straight line (initiator) and the generator structure. To obtain the required Minkowski fractal shape also can be used the Iterated Function System (IFS). It is somehow similar to Koch curves where equilateral triangles are used but in Minkowski geometry the rectangles are used [7-8], [11]

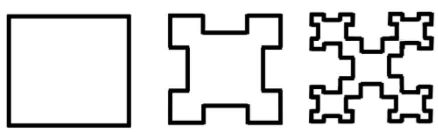


Figure 17: Minkowski Curve

h. Cantor set

Cantor set is developed in 1883 by Georg Cantor who is a German mathematician.The Cantor set is also obtained as the limit of an iterative process. The processbegins with the closed unit interval on the number line, i.e. thefirst step of the iteration removes the middle third of the interval [0, 1]. That is, all the points in the open interval (1/3, 2/3) are removed, but not the endpoints 1/3 and 2/3. Thus,there are two closed intervals remaining: [0, 1/3] and [2/3, 1]. Notice that the part of the Cantor set that lies in the interval [0, 1/3] is simply a copy ofthe entire Cantor set multiplied by the scale factor 1/3. The same is true for the part in theinterval [2/3, 1]. This is the self-similarity property for this fractal [15].

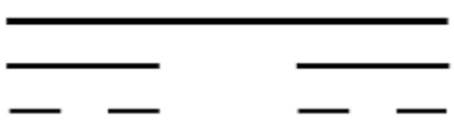


Figure 18: Cantor set

PropertiesofMicrostripFractalAntennas

The following lists some light on some unique properties of the fractal antennas which have made the immensely popular [3-4]

i. Fractalsareself-similarstructures.Theyarecreatedbyusingcopiesofitbutat different scales. The entire geometry is similar to the initiator and is easy to design.
ii. Fractal antennas have the space-filling property. This property leads to the packing of more and more antennas in small volumes i.e. Hilbert Curve.
iii. Fractalantennasaredesignedusinganiterativeprocess.Theseantennasshow multibandbehaviourcorrespondingtoeachiteration.Thussingleantennacanradiate at more than one frequency.
iv. Fractal antennas help to miniaturization size of antenna. These antennas resonate at lower frequencies with smaller physical size as compared to the ordinary antennas.
v. Fractal antennas are easy to model, low profile and fabricate and their cost of fabrication is also very less. It's just etching of copper over some epoxy material.
vi. Fractalantennashavesharpedgesanddiscontinuitieswhichhelptoincreasethe electrical length of the antenna and make it radiate efficiently.
vii. Fractalantennasarerobust.Theyshowmuchpreventionagainstheatormechanical strain.
viii. Fractal e antennas are easy to feed and provide much flexibility to design and fabricate.
ix. Fractalantennasleadtopackingofmoreenergyinsmallervolumewhichresultsin high quality factor.

Literature Review

Different studies have been done by the distinguished researchers to improve the performance parameters of a fractal antennas in the past decades. This review paper mainly deals with the motivation to carry the research on antennas, study of work that has been done by the various researchers and the challenges faced by the researchers. The study of various researchers are listed below:

[3] For Real Time Location System (RTLS) applications PLUS shaped fractal antenna is proposed. The designed and simulated is a fractal antenna is based on FR4 epoxy dielectric substrate with modified ground structure. CST microwave Studio simulation software is uses for thedesign and simulation of the fractal antenna. In this design antenna simulation frequency works from 0-7GHz, but the operating frequency only at 5.782GHz. The bandwidth of this antenna is low.

[4] Proposed fractal antenna which is designed based on the Koch curve geometry. The design antenna has been improved multiple bands at operating frequency between 3-8 GHz and a peak gain of antenna is 4dB with 85 percentages efficiency of antenna. CST Software used for design and analysis of fractal antenna. Gain and Directivity of design antenna is very low.

[5] Presented and investigated a new design hexagonal antenna for wideband applications by using Meander fractal geometries. The proposed antenna has the overall size is 44.92 × 45 mm^2 with the operating frequency bandwidth 2.89 GHz to 6.09 GHz and 7.35 GHz to 8.65 GHz which is suitable for WLAN, WiMAX, X-band for satellitecommunications and point to point high speed wireless communication. Gain and efficiency of design antenna is very low.

[9] The designed microstrip antenna by using Advance Design System Momentum (ADS) in the form of rectangular patch shape.The frequency ranges of antenna is 3.1GHz to 5.1 GHz and its operating frequency at 4.1GHz with the reflection coefficient is less than -10dB. Glass Epoxy dielectric substrate (FR4) with dielectric constant 4.4 and loss tangent (tan δ) equal to 0.02 is used for design rectangular microstrip patch antenna.Transmission lines or microstrip line feeding technique is used for excited electromagnetic wave forrectangular patch of particular length and width.The designed rectangular antenna parameters like S parameters directivity, gain and efficiency are attained from Advance Design System Momentum (ADS).

[11] Designed and Analysis a rectangular Fractal antenna with Koch Fractal Monopole Antenna for multiband application. The structure of this antenna is based on fractal geometrics and its feeding techniques uses microstrip line. Antenna parameters such as gain, VSWR, Bandwidth, Return loss and Directivity are discussed and analyzed. HFSS (High Frequency Structure Simulator) software is used to Design and Analysis of a designed fractal antenna. The designed frequency range has been between 0.8 GHz to 3 GHz. It can use for mobile antenna and Wi-Fi antenna.

[15] Presents a new design method for compact size of dual band pentagonal ring fractal patch antenna by using coplanar waveguide (CPW)-fed. This designed antenna can be generates two wide resonant frequency bands with return loss less than 10 dB at 3.5GHz WiMAX and 5.5-GHz WLAN.CST microwave Studio simulation software is used for optimization, numerical analysis,and EM demonstrating of the prototype structure. ANSYS HFSS isemployed to evaluate an antenna performance in terms of radiation pattern, realized peak gain, impedance bandwidth, and efficiency. The simulation out puts show that pentagonal ring fractal patch antenna has a compact size ($22x22x1.6mm^3$) the design is and manufactured cost is vey low. Design antenna is simulated from 0-10GHz frequency ranges, but operating frequency only at 3.5 and 5.5 GHz. The bandwidth at both operating frequency is low or 500 MHz.

[20] Presents a CPW fed Apollonian Gasket Fractal antenna loaded with Tri-mode Electric Ring Resonator for multiple frequency band application is demonstrated. The design of AGF is done on FR4 epoxy substrate which has dielectric constant of 4.4 and thickness of 1.6 mm. Multi band can be obtained by placing a TERR beneath the CPW structure of the antenna. The proposed antenna has better band width impedance and the radiation operating bands at 2.91 GHz, 6.03 GHz, 8.09 GHz, 11.35 GHz, 15.87 GHz bands with return loss less than 10dB and it is cover up the frequency ranges of Wi-Fi, X-band uplink, IEEE 802.16e, S/C/X and Ku band.

[21] Proposed fractal antenna which is circular shape is designed for the application of satellite communication. The fractal antenna design, simulated and implemented by using Rogers RT5880 dielectric substrate with modified ground structure. This antenna can be used for satellite communication which is operate at frequency ranges of X band, K band and Ku band. CST studio suite version 2016 software is uses for the design and simulation of the fractal antenna. The results of antenna is given in terms of VSWR, gain and directivity. The dimension of ground plane and substrates are large, these need high cost and large place. Design antenna simulated from 0-10GHz its operating frequency only at 8.675GHz. Its VSWR is approximately equal to 2.

Advantages and Disadvantages of Fractal Geometries

a. Advantages of Fractal Geometries [12], [16], [19]
   - Miniaturisation.
   - Has well input impedance matching.

- It have wideband and multiband.
- It provides over huge frequency range reliable performance.
- By using fractal geometrical approach there will be reduced mutual coupling in array antennas.
- Added inductance and capacitance without components.

b. Disadvantages of Fractal Geometries [12], [16], [19]
- Design and Fabrications are complex
- Numerical limitations
- In some cases it has lower Gain
- After first iteration the performance of antenna starts to decrease in some case.

Application of Fractal Antenna

There are wide ranges of applications of fractal antennas. Some of them are discussed below:

- Radio and television broadcast services
- Mobile and Satellite communication
- Direct broadcast services(DBS)
- Command and Control systems
- Remote sensing
- Feed elements in complex antennas
- Satellite navigation receivers
- Integrated antennas
- Biomedical radiators and intruder alarms
- Doppler and other radars

1. Building Communication:
A fractal antenna technology is one of back bone in building communication applications due to provide wideband and multiband frequency. Here, fractal antennas deliver excellent Omni directional coverage with operating frequency range between over150MHz to 6GHz in a compact form factor [1], [12].

2. Global Positioning Systems (GPS) Applications:
Today fractal antennas are widely used for global positioning system with substrate material having high dielectric constant. These antennas are very compact, quite expensive and circularly polarized, due to its positioning. Normally, population for aircraft, land vehicles and maritime vessels millions of GPS receivers will be used to find their position accurately. Some receiving fractal antennas has been designed for GPS applications will be low gain, circularly polarized and small size operating at L-Band [10], [19].

3. Wireless Networks:
Wireless protocols like WiMAX, Bluetooth, WLAN, Zig Bee and MIMO to deliver their maximum potential, provide an excellent advanced antenna technology, so that fractal Antenna is widely appropriate in wireless networks [1], [16].

4. Universal Tactic Communication:
The cognitive radios in the future it will be used for communications systems with one fractal antenna that need vast band widths [1], [12].

5. ***Directto Home (DTH) Applications:***
*D*irect to home used to delivered television services to people broadly. As a receiver most people can be uses at raditional parabolic antenna with its gain about33dB and frequency range between 11.5GHz to 12GHz. This antenna is suffers severely from environmental interconnections like snow and rain. Hence, these antennas can be less effected by environmental issues, take less space and even can be hanged on building wall sand cheap as compared to traditional parabolic antennas, for this requirements patch arrays antennas are an appropriate [19].

6. ***Mobile Devices:***
Now a days wireless devices from PDAs to cellular phones to mobile computing require high performance, compact size and multiband antennas. Therefore, fractal antennas are appropriate for mobile devices and various types of fractal antennas have been designed for use in mobile device systems [12], [14].

7. ***Radio frequency identification (RFID)***:
RFID applications can be widely used fractal antenna with compact size and versatile. Fractal antenna can be used for the purposes of transportation, logistics management, manufacturing, health care and traffic toll collection. Generally RFID system is a transponder or tag and a reader or transceiver system commonly uses frequencies between 30 Hz and 5.8 GHz depending on its application [10], [14].

8. **Wideband Application:**
Wideband characteristics antenna can be attained by applying different iterations to fractal geometry. Super wideband and ultra wideband applications can be commonly uses a fractal antenna.

9. ***Rectenna Application:***
Rectenna is a special type of an antenna known as a rectifying antenna that is used to convert microwave energy into DC power directly. There are four basic a combination of Rectenna such as ore rectification filter, rectifier, post rectification filter and antenna. To meet the demands of long-distance links, in rectenna application it is essential to design antennas with very high directive characteristics. Because the objective of the rectenna is used to transfer DC power through wireless links for a long distance, this can be completed by increasing the electrical size of the antenna [10].

Conclusion

This review paper summarizes a brief literature survey about the fractal antenna and its applications. From the paper we conclude that the fractal geometries improve the antenna the bandwidth up to a great extent. Small size, low profile, low weight, high efficiency and high antenna gain are properties of fractal antennas discussed in the paper. In fractal antenna the metallic portion is reduced due to the use of various fractal geometries. One of the techniques to improving these factors cutting slots in patch by using fractal geometry used to reduce the overall size of fractal antenna. Multiband or wide band can be produced by making use of a single antenna. So that, fractal antenna can be used for various wireless applications such as Satellite communication, mobile communication, Bluetooth, GSM, RFID, WiMAX, GPS, WLAN, RADAR, Point-to-point high speed modern wireless communication.

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