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Research Paper

Fractal Antenna Design for Multiple Applications

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Abstract

The sudden development in in wireless applications has leveled up the use of antennas. Multiband antennas are used to operate at different frequencies for the reliability in various applications. This paper presents design of a novel fractal antenna for multiband applications. Attributes of proposed antenna are simulated using Ansoft HFSS. Due to the homogeneous property in the design of proposed fractal receiving wire it has the various multiband applications. Proposed Antenna design consists of FR4_epoxy material with dielectric constant of 4.4, height 1.6 mm. The operating frequency is taken as 2.4GHz. The antenna is simulated. The proposed antenna resonates at different frequencies. The results are measured and return losses are compared. Here the geometry of fractal antenna is analyzed for the C band resonating at 6.2 GHz, X band resonating at 11.9 GHz and Ku band resonating at 13.8 GHz for S11<-10db.

Keywords: *Multiband antenna, C band, X band, Ku band, Return loss, HFSS.*

1. Introduction

A Micro-strip fixed patch Antenna includes an exuding patch and ground plane on either side of a dielectric substrate. A smaller scale strip Antenna is a directional antenna, which transmit more power in some particular direction than the others. The fundamental kind of rectangular fix antenna involves a transmitting patch on one side of a dielectric substrate which has a ground plane on the opposite side.

Fractal is an eccentric geometric shape subdivided in parts, every one of which is a little size copy of the entire shape. Latin word fractus whose significance is broken, used to infer the word 'Fractal'. In fractal antenna, we partition the entire antenna into small duplicates of itself which implies the antenna is divided into parts which enhances the efficiency of the antenna. The advantage of fractal geometry is to design small size antennas and second is it can work at various frequencies.

There are various accessible shapes for fractal reception apparatus, for example, Sierpinski cover, Sierpinski gasket, Koch, Hilbert bends are available. Their fundamental reason is to reduce the complexity in multiband applications. Ordinarily, the operational frequencies are controlled by the sort of fractal utilized as a part of the design. Nowadays, there are higher development & demand in correspondence for witreless applications. Multiband or wideband and low profile antennas are in higher request. This request is satisfied by utilization of the fractal antenna as a result of its self-similarity and self-redundant properties.

2. Literature Survey

The author in [1] mainly focused on the optimization of structure behaviour by generating the parameterized values which help automation of the multi-objective optimization Numerical results are highlighted optimal values of S-parameters in the considered frequency. These pre-fractal antenna only designed for 2 particular frequencies.
The author In [2] mainly focused on Minkowski fractal antenna with square patch element. The substrate used for this design is FR-4 the proposed design whose dielectric constant 4.4 respectively. The square patch element is located in center of Minkowski fractal patch antenna. The studies here are frequency, VSWR, Return Loss, Bandwidth, Radiation Pattern, Smith Chart and gain. The targeted frequency of this antenna is designed for Radio location application and WPAN (It can be used for several applications in X-band and Ku-band).Design is very complex structure and the return loss obtained is more.
The author In [3] essentially centered around plan of Modified Sierpinski Carpet Fractal Antenna which works at 6 distinct frequencies. Distinctive performance parameters like radiation design, gain, VSWR, return losses are observed for every one of the frequencies. The FR4 glass epoxy with relative permittivity 4.4. Reception apparatus is sustained by coaxial probe. Proposed receiving wire has basic structure. Examination is done between the frequencies 1 and 10 GHz .This is not regular current dissemination trail and blunder technique.
The author in [4] primarily centered around watching the behaviour of the Koch monopole numerically and tentatively. Then, the outcomes demonstrated that the number of iterations on the small fractal Koch monopole were expanded. In all existing methods, it is observed that the antenna size and weight is not considerable. These

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antennas are operated only in few frequencies and the feed used is coaxial feed, which is complex to design. Usages of coaxial feed results in low gain, high return losses and spurious signals.
The author in [5] has developed fractal antenna for satellite communication. In this paper they planned single fractal antenna for multiband purpose of satellite applications. These proposed reception apparatuses are small in measure and can work in different groups, for example, L, S, C and X band. Here 3 unique outlines are proposed for receiving wire in view of various feeding strategies and their geometry[18-29]. All plans are fractal geometries. These are antennas only for satellite navigation and for remote sensing.

Considering all these parameters a novel design is proposed with low profile which has better gain and capable of operating at multiple frequency bands.

3. Proposed Antenna Design Parameters and Configuration

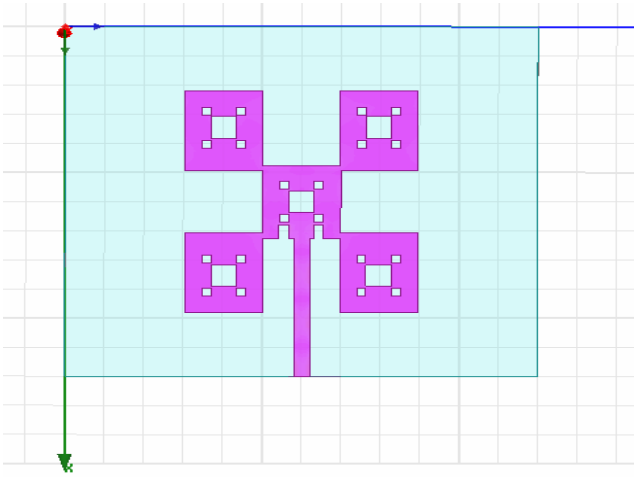


Fig.1 Geometry of the proposed antenna with top view

The figure.1 can represent the proposed fractal antenna model. Micro-strip line feed is used for this Fractal antenna. The design starts with rectangular patch which operates at resonant frequency of 2.41 GHz, By considering the values of εr = 4.41, f0 = 2.41 GHz, h = 1.60 mm and C = 3.9x108m/s.

Calculation of Width (W): The width of the patch element (W) is calculated using equation

$$w = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Effective dielectric constant εeffis calculated using following equation

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{1/2}$$

Effective length of patch is calculated using equation,

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Extension in length of patch is calculated using equation,

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

The actual length (L) of patch is calculated using following equation,

$$L = L_{eff} + 2\Delta L$$

Table 1: Antenna Design Parameters

Dielectric substrate (FR4): εr	4.41
Substrate height (h)	1.60 mm
Patch width (Wp)	38.004 mm
Patch length (Lp)	29.440 mm
Substrate width (Ws)	60 mm
Substrate length (Ls)	60 mm

3.1 Design steps in HFSS

The basic idea of proposed fractal antenna to increases the length of the proposed antenna by minimizing its shape. The geometry-Fractal has been till date very useful for multi band applications.

Step1: The Length & width of patch is 29.440 and 38.004 mm. Substrate width and length are considered as 60.00 mm each (base geometry).

Step2: Divide base geometry into nine congruent sub-rectangles in a 3*3 grid & remove one central rectangle from each outer grid.

Step3: Divide each metallic rectangle of iteration-I geometry into nine congruent sub-rectangles in a 3*3 grid, and remove one central rectangle from each this metallic rectangle to get iteration-II of fractal antenna.

Step4: Similar process is repeated to get iteration-III geometry as shown in Fig 1.

4. Results and Discussions

This proposed fractal antenna is designed and optimized with the simulation tool Ansoft HFSS ver. 14.0. Fig.2 representing return loss for the antenna operating at C, X and Ku frequency bands, Y axis representing scattering parameter value and X axis representing frequency.

4.1 Return Loss: S11 talks about how much power is reflected from the radio wire, and in this manner is known as the reflection coefficient or return loss.

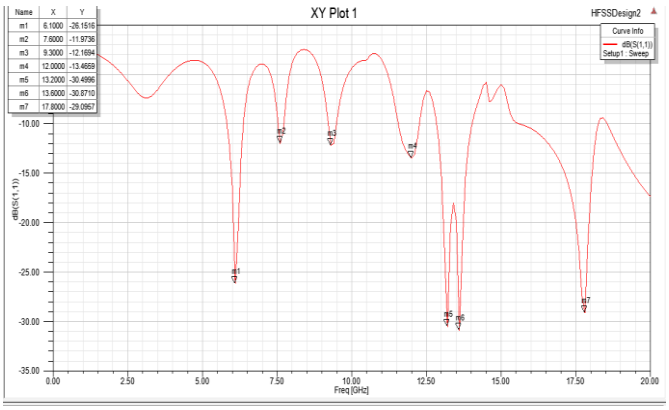


Fig. 2 Return loss

Above S Parameter graph illustrates 5 different frequencies operates in 3 different bands. They are:

- Two frequencies 6.200 GHz and 7.60 GHz in **C -Band (4 to 8 GHz).**
- One frequency 11.9 GHz in X **–Band (8 to 10 GHz).**
- Two frequencies 12.80 GHz, 13.80 GHz **Ku –Band (12 to 18 GHz).**

All the frequencies are considered at S_{11} < -10db.

4.2 Radiation Pattern:

The procedure by which antenna radiates can be effortlessly defined as far as the path in which its quick movement of charged particles or time-shifting currents. The radiation pattern of the antenna is shown in Fig.3.

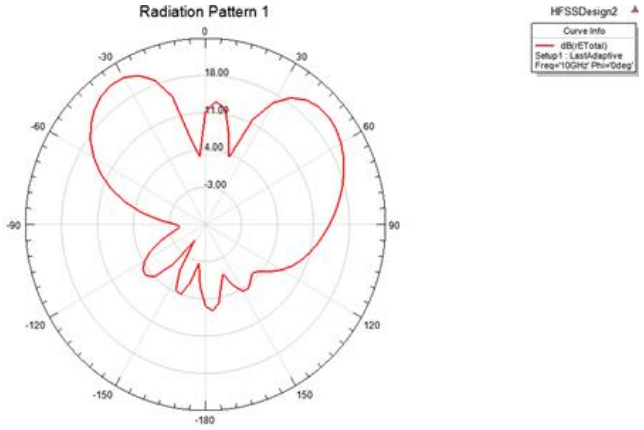


Fig. 3 Radiation Pattern

4.3 VSWR:

If the input of the antenna not matched with the receiver of the antenna then there will be reflection coefficient which will not be equal to zero. And standing waves are created along the transmission line due to this reflected voltage wave. If VSWR value is equal to 1 then there will not be reflected power or reflected voltage at antenna. Simulated & measured radiation patterns for antenna. The VSWR values are shown in Fig.4.

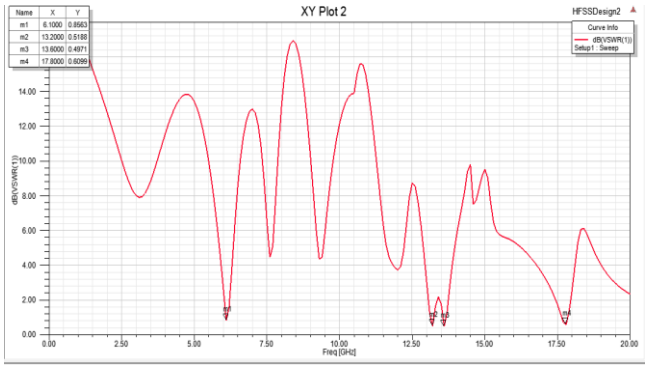


Fig. 4 VSWR Values

The dominant part of counts for radio wire impedance, protection, radiation protection, reactance, radiation design and so forth depend on strategies utilizing the general receiving wire current conveyance bend. Most of the current distributed across the Micro strip line feed this is magnetic field of current distribution.
The Simulated and measured results of proposed antenna in terms of S parameter, VSWR and gain.
Directivity deals with the directional abilities of that particular antenna whereas the gain also deals with the efficiency in addition to the directional abilities of the antenna and impedance mismatches and polarization losses are not considered into account while gain is obtained for the given antenna. Gain is a dimensionless quantity.
All the obtained parameters of the proposed antenna are tabulated and compared with the existing antenna as shown in Table 2.

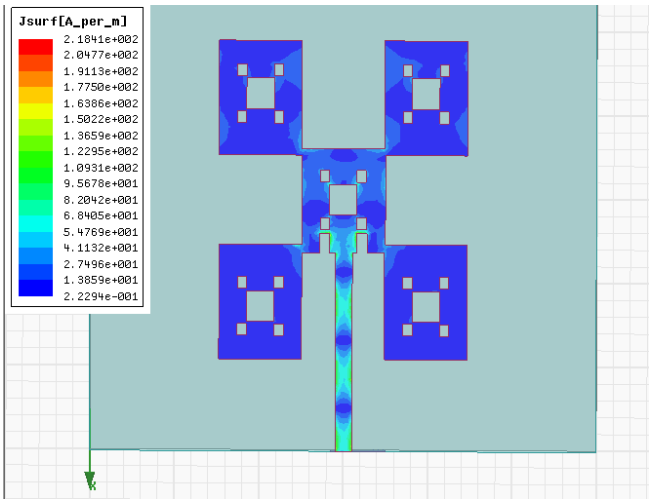


Fig. 5 Simulated Current Distributions

Table 2: Comparison between proposed method and previous method

Parameters	Existing Method	Proposed Antenna
Bands	C,X bands	C, X, Ku bands
Frequencies	4.825GHz, 5.455GHz 6.265GHz , 6.805 GHz 8.02GHz, 9.145 GHz	6.100GHz,7.60GHz, 9.30 GHz,12.00 GHz, 3.20 GHz, 13.6 GHz 7.800 GHz
Gain	3.38dBi	2.26dBi
Spurious signals	High	Low

5. Applications

The proposed antenna can be operated in different frequencies and 3 frequency bands. The obtained frequency bands are C- band, X-band and Ku- band. The different applications of the proposed antenna are described in the following.

C-band: C-Band is the first recurrence distribution for interchanges satellites. C-Band utilizes 3.71-4.22GHz for downlink and 5.915-6.435Ghz for uplink. The bring down frequencies that C Band utilizes perform preferred under unfriendly climate conditions over the Ku band or Ka band frequencies.

X-band: Military applications like missile guidance, marine radar, air-borne tracking and government applications like remote detecting, versatile systems administration, and airborne insight, observation, and surveillance (AISR) rely on government and business satellite frameworks.

Ku-band: The Ku band (Kurtz-under band) is essentially utilized for satellite interchanges, especially to editing and broadcasting satellite TV. This band is part into numerous sections separated into topographical areas, as the ITU (International Telecommunication Union) determines. Fixed satellite service (FSS) like television transmission, Broadcast Satellite Service (BSS) like telecommunication, wireless communication and Satellite altimetry.

6. Conclusion

This geometry offers various varieties in measurement and configuration, thus gives wide degree for different commercial applications. And we used Micro strip line Feed which gives the spurious signals so, feed should be changed to co-axial feed for less spurious signals. The result confirming that frequency was left shifted

whenever dimension is raised whereas fractal scale changes potentially structure characteristics (S-Parameters) with lower fractal scales and enforces the bad S-Parameters for the higher fractal scales. Proposed Antenna can be utilized for long separation radio broadcast communications in Ku band and additionally satellite correspondence, radar, space interchanges in X band. The key highlights of this radio wire is its ease in development utilizing fractal geometry. The proposed antenna resonates at 6.2 GHz, 11.9 GHz and 13.8 GHz for C, X and Ku bands respectively.

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