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Design and Analysis of Circular Patch Fractal Antenna for Radar Application

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Abstract: This paper proposes the design of a circular patch antenna with fractals for X-band applications. The designed antenna is fedwith proximity coupled feeding technique and fractal structure produces a dual band operation for the X-band applications. The simulated results for various parameters like return loss, radiation pattern, directivity is presented. The designed antenna operates for dual band at 8.2 GHz and 11.4 GHz with increase in Gain and Bandwidth. Especially the proposed antenna used for radar communication ranging from 8.29 GHz to 11.4 GHz. This type of antenna is useful in Telecommunication, Wi-Fi, Satellite communication, Radar, Commercial and Military application.

Key words: Circular patch · Fractal antenna · Return loss · Directivity · Voltage Standing Wave Ratio

INTRODUCTION

Fractals are space-filling contours, meaning electrically large features can be efficiently packed into small areas [1]. Since the electrical lengths play such an important role in antenna design, this efficient packing can be used as a viable miniaturization technique. In other words Fractals are broken or irregular fragments, generally shaped composed of multiple copies of themselves at different scales [2]. This fractal geometry, which has been used to model complex objects found in nature such as clouds and coastlines, has space filling properties. This space filling properties is useful to minimize the size of antenna. The space-filling property of fractals tends to fill the area occupied by the antenna as order of iteration is increased [3]. Fractals are broken or irregular fragments, generally shaped composed of multiple copies of themselves at different scales. In other words we can define fractal as a rough or fragmented geometric shape that can be subdivided in parts, each of which is a reduced-size of the whole structure. Some attractive features of fractal antennas are self-similarity and space filling properties, which are used to generate antennas having multiband characteristics [4]. For most fractals, similarity concept can achieve multiple frequency band because of different of antenna are similar to each other at different scale. It has been found out that proximity coupled feed order less dispersion at higher frequency and in broader matching as compare to micro strip feed. This paper presents the proximity coupled circular patch multi-wideband antenna of compact size [5].

Antenna Geometry: The antenna structure based on fractal geometry shown in Fig. 1(a). This antenna has been designed on dielectric substrate εr= 4.4, thickness = 1.6mm with proximity coupled feed. A circular patch antenna of a radius a = 10.15mm has been taken as a base to construct fractal antenna. The 2nd iterative structure has been generated from this circular patch. In the 1st iteration shown in Fig. 1(b) we divide this circle into one smaller circle with radius a= 2mm and then removed the circle at the centre as the remaining circle is four. In the 2nd iteration shown in Fig. 1(c) we divide each remaining four circle into one circle with radius = 1 mm. Then drop the entire centre circle for each remaining circle. The antenna is fed with proximity coupled feed. To obtain a large bandwidth this type of feeding is used. This antenna not only performs better in respect of bandwidth but radiation pattern is also good. It is also relevant to relative permittivity and thickness of substrate.

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Design Methodology:

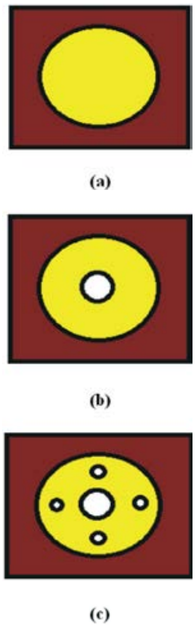

Fig. 1: Geometry of the fractal antenna, (a) 0th iteration (b) 1st iteration (c) 2nd iteration

Figure 1(a) shows initially a reference patch is designed, which is circular in shape. After designing reference patch a series of iteration involving etching is carried out. In Figure 1(b) shows first iteration of proposed antenna, the centre portion of the reference patch is etched in the shape of a circle. In Figure 1(c) shows second iteration of proposed antenna, five consecutive etching is carried out, in the shape of circles, surrounding the circle etched at the centre of the reference patch.

Simulation Results:

Reference Patch Antenna Results: Figure 2 shows proposed antenna with the return loss -20.216dB and-25.815dB at a frequency of 8.2 GHz and 11.4 GHz. The proposed antenna design gives good impedance of approximately 50 ohms.

Circular Patch Antenna-First Iteration Results: Figure 3 shows the proposed antenna (first iteration) with the return loss of -26.324 dB and -31.067dB at the frequency of 8.2GHz and 11.4GHz.

Circular Patch Antenna-Second Iteration Results: Figure 4 shows the return loss plot of proposed antenna (second iteration), resonates at the frequency of 8.2GHz and 11.4GHz having bandwidth 105 MHz and 115MHz with a return loss of -36.596dB and -42.532dB.

Directivity Results-First Iteration: Figure 5shows the directivity plot represents amount of radiation intensity is equal to 3.0 dBi. The simulated antenna radiates more in a particular direction as compared to the isotropic antenna which radiates equally in all directions, by an amount of 3.0 dBi. From polar plot view of the directivity, it can be observed that at a frequency of 8.2 GHz, directivity is 3.0 dBi, radiation pattern obtained is omnidirectional with main lobe directed at an angle of 152.0 degree, having angular width of 158.6 degree. The magnitude of the main lobe is 3.0 dBi.

Figure 6 shows the directivity plot represents amount of radiation intensity is equal to 3.9 dBi. From polar plot view of the directivity, it can be inferred that at a frequency of 11.4 GHz, directivity is 3.9 dBi, radiation pattern obtained is omnidirectional with main lobe directed at an angle of 158.0 degree, having angular width of 140.6 degree. The magnitude of the main lobe is 3.9 dBi.

Directivity Results- Second Iteration: Figure 7shows the directivity plot represents amount of radiation intensity is equal to 3.9 dBi. The main lobe is directed at an angle of 157.0 degree, having angular width of 123.8degree. The magnitude of the main lobe is 3.5 dBi.

Figure 8shows the directivity plot of proposed antenna at 11.4 GHz represents amount of radiation intensity is equal to 3.9 dBi. The main lobe is directed at an angle of 134.0 degree, having angular width of 187.7degree. The magnitude of the main lobe is 3.4 dBi.

Voltage Standing Wave Ratio Result-First Iteration: The Figure 9 shows the VSWR plot of proposed antenna (First Iteration) frequency to VSWR of VSWR value < 1.3 works on two different frequencies, on the frequency of 8.2 GHz with a bandwidth of 231 MHz with range 8.13 GHz – 8.36 GHz. Next frequency on 11.4 GHz with 105 MHz bandwidth with range 11.37 GHz – 11.48 GHz.

Voltage Standing Wave Ratio Result-Second Iteration: The Figure 10 shows the VSWR plot of proposed antenna (second iteration) frequency to VSWR of VSWR value < 1.3 works on two different frequencies, on the frequency of 8.2 GHz with a bandwidth of 105 MHz with range 8.17 GHz - 8.27 GHz. Next frequency on 11.4 GHz with 114 MHz bandwidth with range 11.34 GHz - 11.46 Ghz.

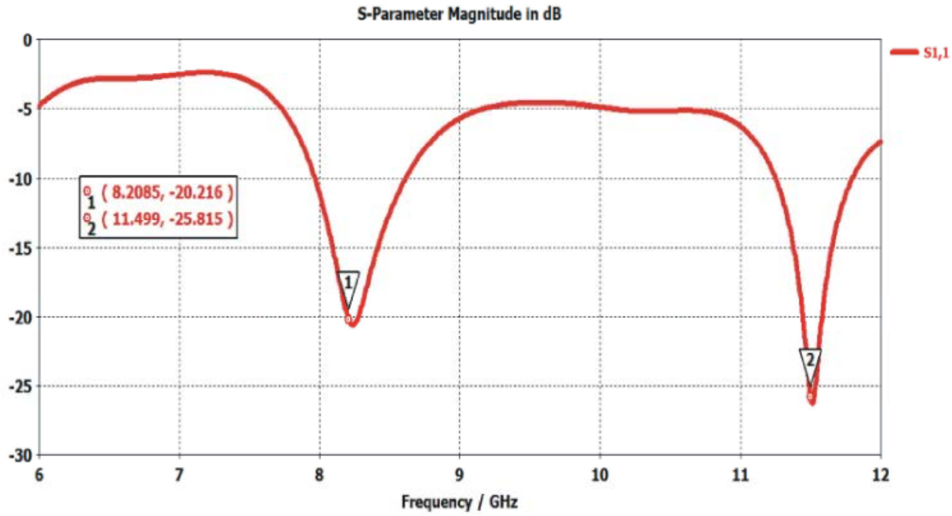

Fig. 2: Return loss plot of proposed antenna

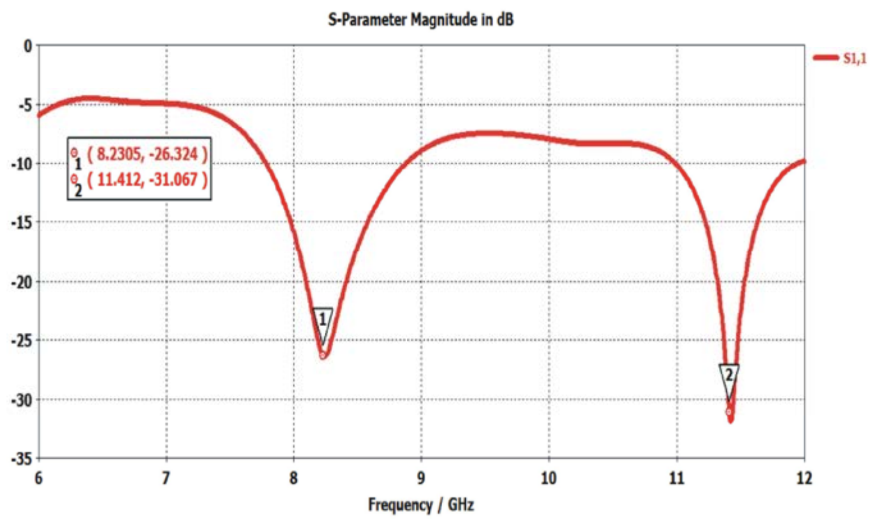

Fig. 3: Return loss plot of proposed antenna (First Iteration)

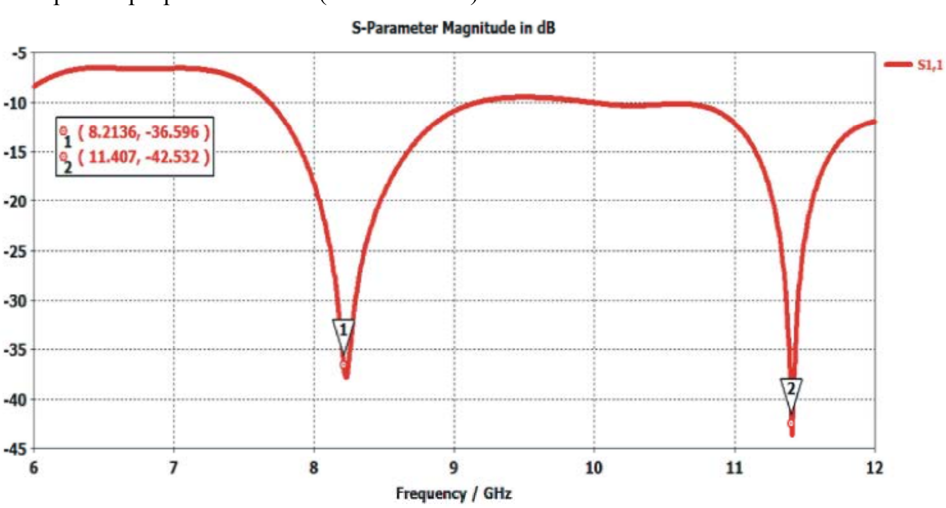

Fig. 4: Return loss plot of proposed antenna (Second Iteration)

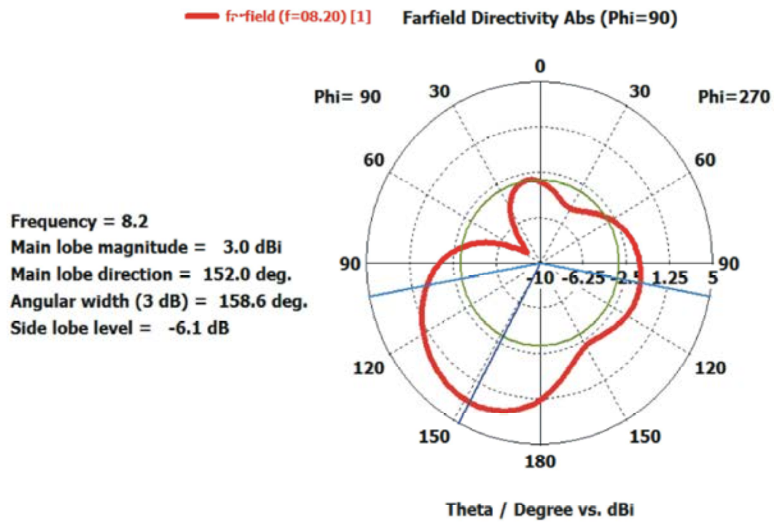

Fig. 5: Directivity plot of proposed antenna at 8.2GHz (First Iteration)

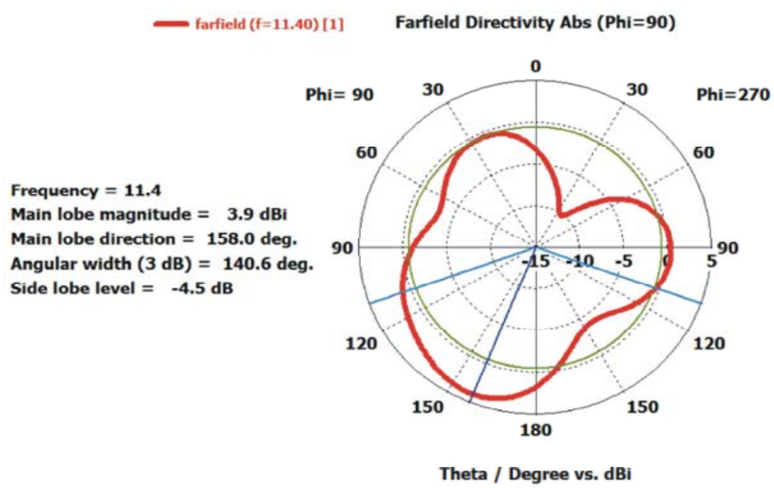

Fig. 6: Directivity plot of proposed antenna at 11.4GHz (First Iteration)

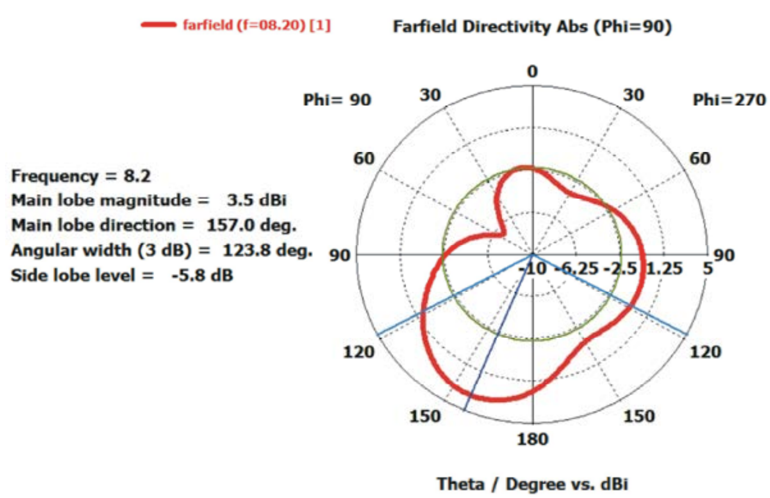

Fig. 7: Directivity plot of proposed antenna at 8.2GHz (second Iteration)

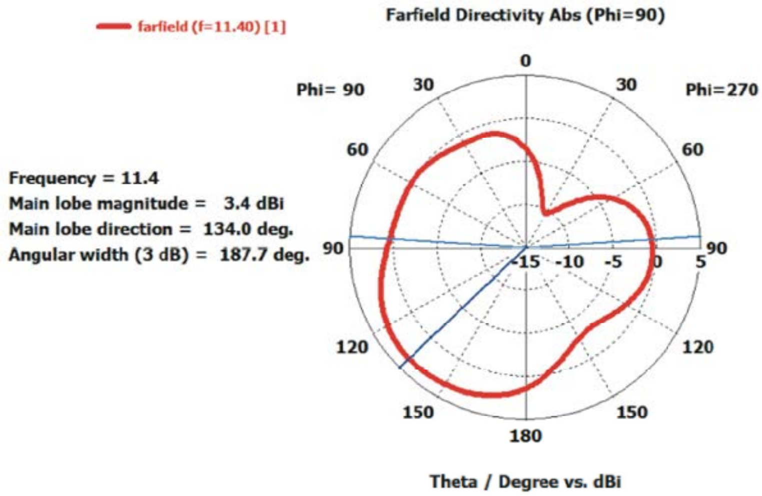

Fig. 8: Directivity plot of proposed antenna at 11.4GHz (Second Iteration)

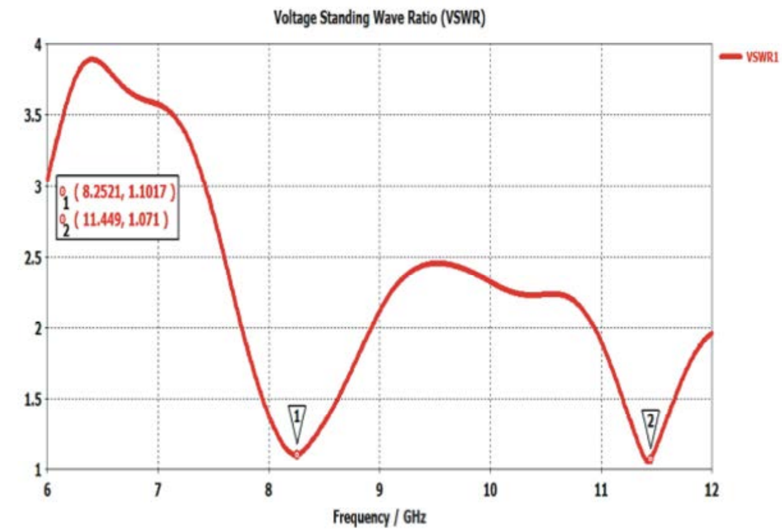

Fig. 9: VSWR plot of proposed antenna (First Iteration)

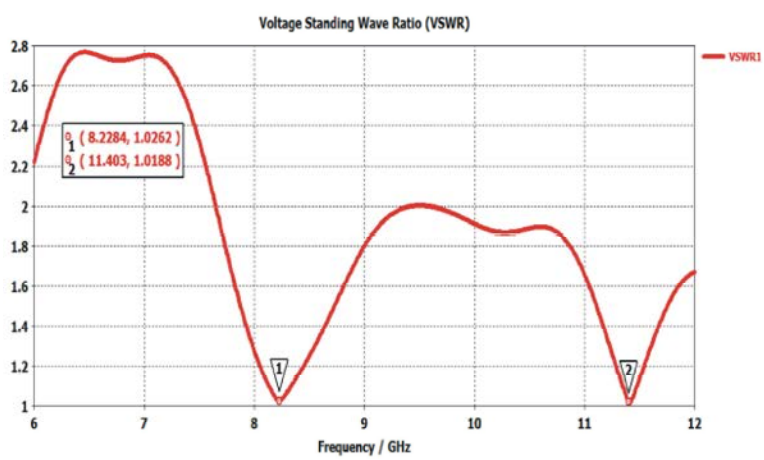

Fig. 10: VSWR plot of proposed antenna (Second Iteration)

CONCLUSION

In this paper, circular patch based fractal antenna is proposed. The proposed circular patch antenna with fractals is designed to exhibit the dual band operation. This antenna order increases bandwidth and directivity over all entire range of frequencies. The designed antenna can be used for dual band applications in X band, useful for Telecommunication. This antenna exhibits reduce return loss, optimum VSWR value and increasing bandwidth and directivity.

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