A Dual Band Fractal Circular Microstrip Patch Antenna for C-band Applications

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Abstract— This paper proposes the design of a circular patch antenna with fractals for C-band applications. The designed antenna has been fed with L probe feeding technique. The proposed circular patch antenna with fractals produces a dual band operation for the C-band applications. The designed model is simulated using CST microwave studio software based upon finite difference time domain method. The simulated results for various parameters like return loss, radiation pattern etc have been presented. The designed antenna operates for dual band at 6.6 GHz and 7.5 GHz with increase in Gain and Bandwidth. Such type of antennas is useful in Telecommunication, Wi-Fi, Satellite communication, Radar, Commercial and Military application.

1. INTRODUCTION

In modern wireless communication system and increasing other wireless applications, wider bandwidth, is required, traditionally each antenna operates at a single frequency band, where a different antenna is needed for different application. This will cause a limited space and place problem. In order to overcome this problem, multiband antenna can be used where a single antenna can operate at many frequency bands. One technique to construct a multiband antenna is by applying fractal shape into antenna geometries [1, 2].

Fractals: fractal shaped antenna have been proved to have some unique characteristics that are linked to geometrical properties of fractals. According to Webster dictionary a fractal is being derived from the Latin fractious meaning broken, uneven: any of the various extremely irregular curves or shapes that repeat themselves at any scale on which they are examined. Fractal geometry has unique geometrical features occurring in nature. It can be used to describe the branching of the tree leaves and plants, jaggedness of coastlines and many more examples in the nature. There are many benefits where we apply fractals to develop various antenna elements. By applying fractals to antenna elements: we can create smaller antenna size, achieve resonance frequency that are multiband, may be optimized for gain, achieved wideband frequency band [3, 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 L-probe feed offer less dispersion at higher frequency and in broader matching as compare to micro strip feed. This paper presents the new L probe-fed circular patch multi-wideband antenna of compact size [5–7]. Such type of antenna is useful in Telecommunication, Wi-Fi, satellite communication, radar, commercial and military application.

In this paper, a design of dual band fractal microstrip antenna has been presented. The designed microstrip antenna in third iteration produces two bands at 6.7 GHz and 7.5 GHz for C-band applications. Rest of the paper is organized as follows: The geometrical configuration of the designed antenna is presented in Section 2. The simulated results and discussion are given in Section 3. Finally, Section 4 concludes the work.

2. ANTENNA GEOMETRY

The antenna structure based on fractal geometry shown in Fig. 1(a). This antenna has been designed on substrate dielectric constant $er = 2.3$, thickness = 4 mm with L-probe fed. A circular patch microstrip antenna of a radius $a = 16$ mm has been taken as a base to construct fractal antenna. The 3rd iterative structure has been generated from this circular patch. In the 1st iteration shown in Fig. 1(b) we divide this circle into five smaller circle with radius = 5.1 mm 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 five circle with radius = 1.35 mm.Then drop the entire centre circle for each remaining circle. The reaming small circle for this stage is sixteen. In the 3rd iteration shown in Fig. 1(d) we divide each remaining sixteen circle into five with radius = 0.2 mm. The entire center circle for each remaining circle is being omitted. The infinite iterative structure is not possible due to fabrication constraints. In this paper, 3rd iterative circular patch antenna has been finalized.

The antenna is fed with L-probe fed. To obtain a large bandwidth this type of feeding is used. In particular, an L shaped probe antenna has an excellent feeding structure suitable for wideband patch antenna with an air substrate. In general, this type of feed can be easily implemented by bending a straight strip or probe into an L-shape. The L-fed antenna not only performs better in respect of bandwidth but radiation pattern is also good [8–10].It is also relevant to relative permittivity and thickness of substrate. In this paper, $er = 2.3$ and thickness $= 4\,\mathrm{mm}$ is used.

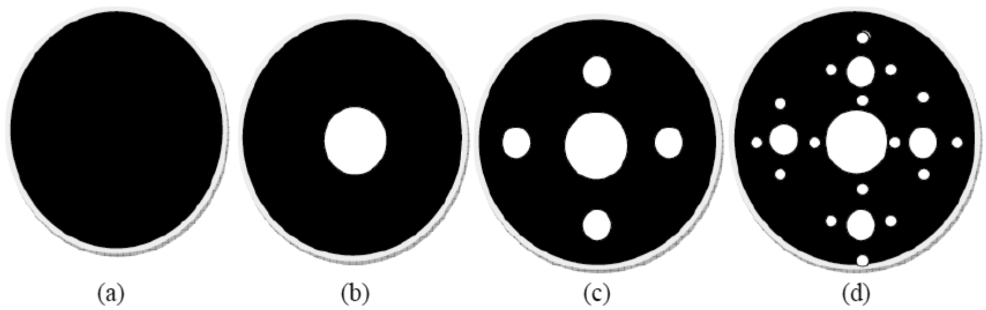


Figure 1: Geometry of the fractal antenna, (a) 0th iteration, (b) 1st iteration, (c) 2nd iteration, (d) 3rd iteration.

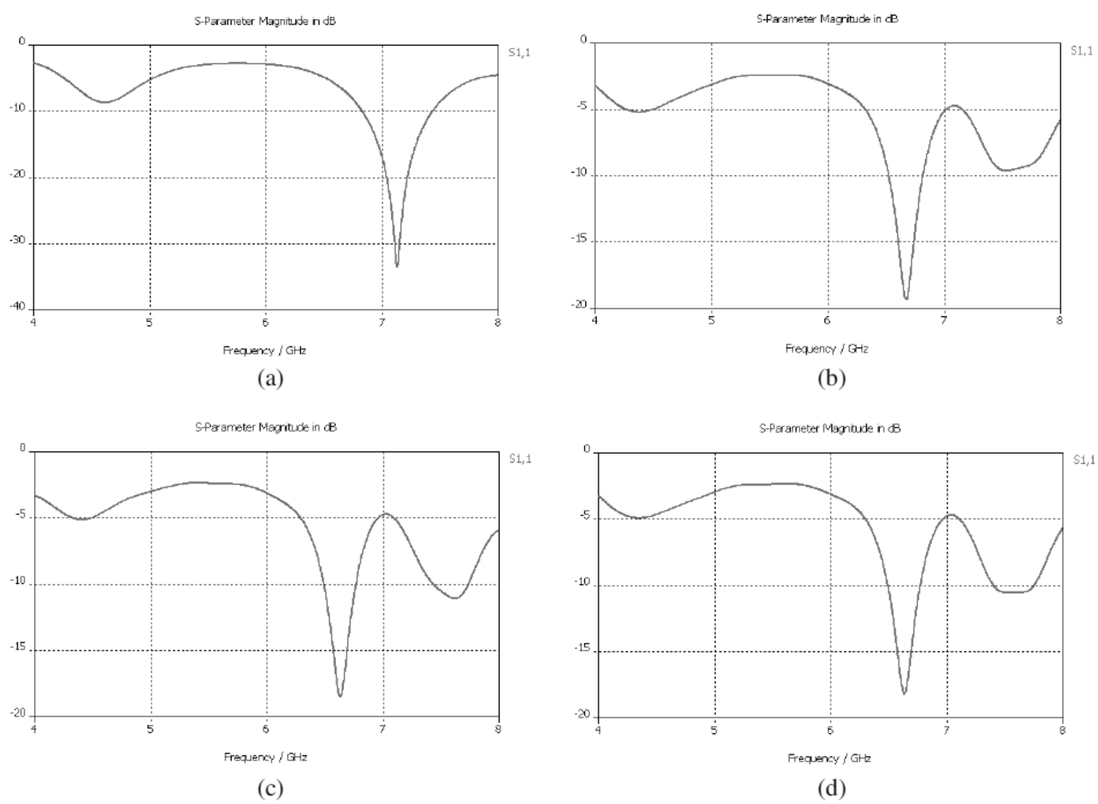


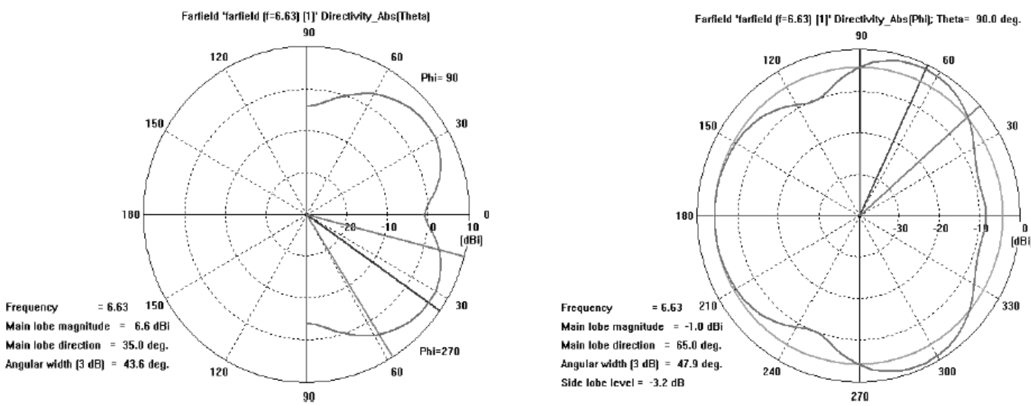
Figure 2: The return loss of the designed antenna, (a) 0th iteration, (b) 1st iteration, (d) 2nd iteration, (d) 3rd iteration.

3. RESULT AND DISCUSSION

As illustrated from Table 1, the bandwidth of antenna for 0 iteration is 0.6198 GHz (6.8243–7.4505), while for 1st iteration is 0.3003 GHz (6.524–6.8243), 2nd iteration are 0.2812 GHz (6.4989–6.7796) at lower band and 0.293 GHz (7.738–7.441) at upper band respectively as well as for 3rd iteration are 0.294 GHz (6.4856–6.7796) at lower band and 0.3706 GHz (7.3866–7.7572) at upper band. As the iteration increases the bandwidth is increases as well as it generates another resonant frequency at 7.5 GHz.

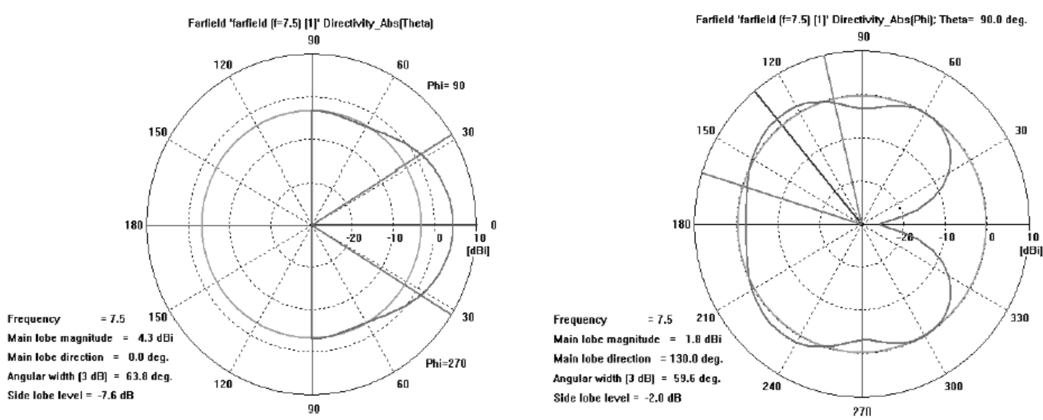
Table 1: Result the simulated circular patch antenna with fractals.

Circular patch antenna	Operating Frequency	Frequency band (GHz)	Bandwidth (GHz)
0th iteration	7.12 GHz	6.8243–7.4505	0.6198 (8.67%)
1st iteration	6.6 GHz	6.524–6.8243	0.3003 (4.5%)
2nd iteration	6.6 GHz	6.4984–6.7796	0.2812 (4.23%)
2nd iteration	7.5 GHz	7.738–7.441	0.293 (3.86%)
3rd iteration	6.6 GHz	6.4856–6.7796	0.294 (4.43%)
3rd iteration	7.5 GHz	7.3866–7.7572	0.3706 (4.9%)



(a) (b)

Figure 3: Radiation pattern of the antenna at 6.6 GHz, (a) theta plane, (b) phi plane.



(a) (b)

Figure 4: Radiation pattern of the antenna at 7.5 GHz, (a) theta plane, (b) phi plane.

Table 2: Simulated results for the designed antenna.

Circular patch antenna	Efficiency	Directivity	Gain (dBi)
0th iteration	0.9923	6.832	6.77
1st iteration	0.9776	6.429	6.28
2nd iteration	0.9807	6.422	6.29
2nd iteration	0.9987	7.636	7.62
3rd iteration	0.9720	6.454	6.27
3rd iteration	0.9904	7.615	7.54

The simulated radiation pattern of fractal antenna for 3rd iteration is shown in Fig. 3 and in Fig. 4. The gain result for simulated circular patch with fractal antenna at different iteration is shown in Table 2. From this table it is clear that the efficiency of the antenna is very high.

4. CONCLUSIONS

The circular patch antenna with fractals has been designed to exhibit the dual band operation. This antenna offer increase in bandwidth and gain at all multiband. The designed antenna can be used for dual band applications in C band. Such type of antenna is useful for Telecommunication, Wi-Fi, Radar, Satellite communication, Military and commercial.

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