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Cross Polarization Minimized Fractal Antenna for HiperLAN Application

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Abstract: Two Fractal based antennas are proposed here for HiperLAN applications. Cantor Square fractal antenna has a size of 30mm×20mm×1.6mm and Sierpinski Carpet antenna has a size of 30mm×25mm×1.6mm. To reduce Cross polarization stubs have been introduced in the feed line and thereby achieving polarization purity for the above said antennas. Both antennas can resonate at a 5GHz band with good return loss and low cross-polarization. Cantor fractal and Sierpinski Carpet at its 2nd iteration gives up to -60dB cross polarization with a return loss at -35dB making these designs good for LAN applications

General Terms: Antenna.Fractal Geometry, Microstrip, Low profile.

Keywords: Miniaturization, Cantor Square, Sierpinski Carpet, HiperLAN, Cross Polarization.

1. Introduction

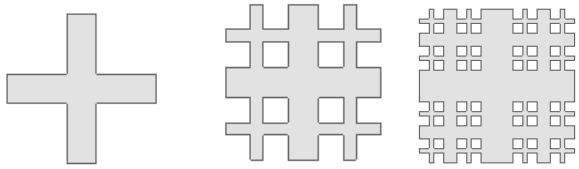
Fractals are the geometries in which each & every portion will be a replica of its own bigger versions. Benoit Mandelbrot first suggested the term Fractal in his book "The fractal geometry of Nature". The scaling down to a smaller size gives not only gives miniaturization but also enables the antenna to resonate at multiple frequencies. Along with the parameters such as gain, return loss, and VSWR, Cross polarization is also a major concern while designing an antenna. It is the phenomenon that refers to the polarization of the transmitted or received signal which is different from the desired polarization. It is also the ability of an antenna to reject signals having polarization other than the intended one.

Antenna miniaturization became a key concern for researchers these days. Fractal geometry has been used for this purpose widely. [1], explains how the fractals can be used for miniaturization also it explains the reduction in resonant frequency caused by the signal coupling between wire angles. Giuseppe Peano Fractal Geometry is used to get miniaturization by adding slots in its structure [2]. Hilbert geometry can also be used for the miniaturization of the fractal antenna where it utilizes a space-filling nature and therefore can reduce the total size antenna.[3].

It is economical to use Multi-band antennas to receive multiple applications that are arriving at different frequencies than single antennas for each frequency. Such a system based on the Sierpinski gasket is proposed in [4] and shows self-similar behaviour at multiple frequencies. A Hexagonal fractal proposed in [5] has predictable multiband behaviour. A fractal antenna with Koch hexagonal shape for S, C, and X bands is presented in [6] also the size reduction of 43% is achieved using fractal geometry. Hilbert monopole loaded with SRR is explained in[7] where cross-polarization is also reduced along with multi-band operation.An Inverted F antenna for HiperLAN is explained in [8] which can be used for ISM band also. A Multi-Band Coupled-Fed Antenna is proposed by Ming-An Chung in [9] in MIMO configuration. A compact antenna for ISM and WLAN is proposed in [10] by Azimov Uktam which has omni directional pattern.

2. Antenna Design

FR4 substrate which is most popular for Antenna design is used here for making the antenna. Cantor Square Fractal & Sierpinski Carpet designs have been generated on FR4, and both of them show good radiation characteristics. The dielectric constant of FR4 is 4.4 and the thickness chosen was 1.6mm



(a) (b) (c)

Fig 1. Cantor square fractal iterations (a) initiator (b) 1st iteration (c) 2nd iteration

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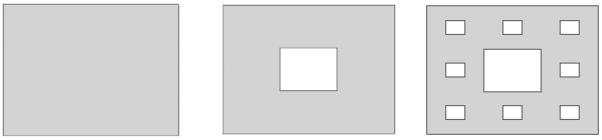
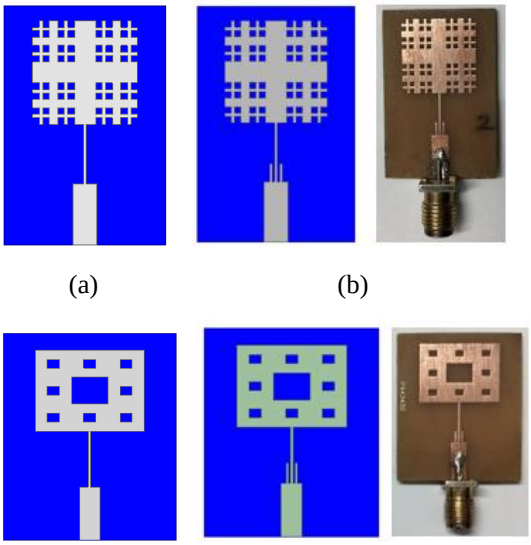


(a) (b) (c)

Fig 2. Sirpinski carpet fractal iterations (a) initiator (b) 1st iteration (c) 2nd iteration

In both antennas for iteration progress, the design ratio is taken as 1/3. To get good matching, an impedance matching network has been added which includes a quarter-wave transformer & a feed line of 50Ω impedance. From the results taken, it was found that the cross-polarization is low for these antennas & to reduce the cross-polarization, two stubs have been added to the feed line which reduces the cross-polarization to a reasonable level.



(a) (b) (c) (d)

Fig 3. Antenna Structure (a).Contor Fractal without stub (b) Contor Fractal with stub at its 2nd iteration (c) Sierpinski Carpet Fractal without stub (d) Sierpinski Carpet Fractal with stub at its 2nd iteration

Table 1 . Design Parameters of Cantor Square fractal antenna

Component	Dimension in mm
L1	30
W1	20
W2=L2	12.5
W3	3
L3	5
L4	7.5
L5	7.67
L6	2.25

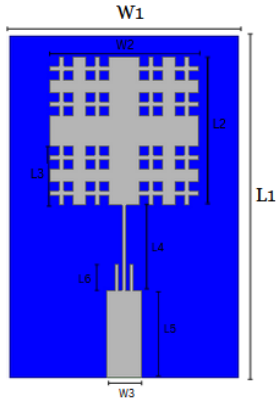


Fig 4: Cantor Square fractal antenna with parameters

Table 2. Design Parameters Sierpinski Carpet Fractal antenna

Component	Dimension in mm
L1	30
W1	25
W2=L2	11.72
W3	3
L3	3.91
L4	8.14
L5	7.67
L6	2.95

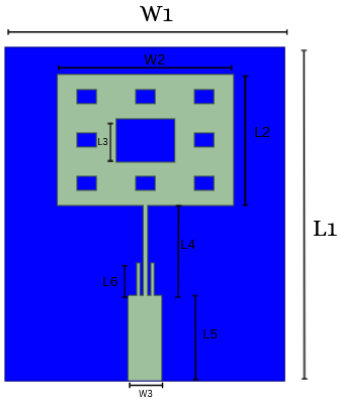
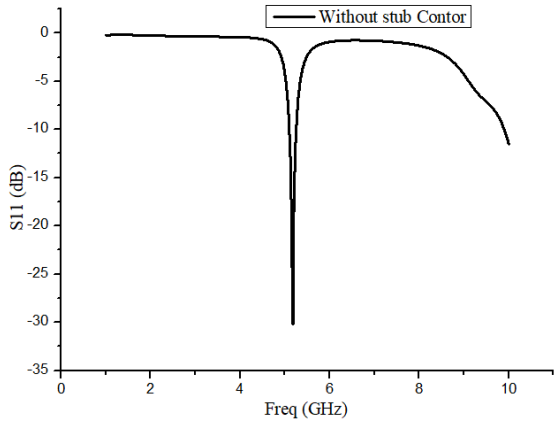


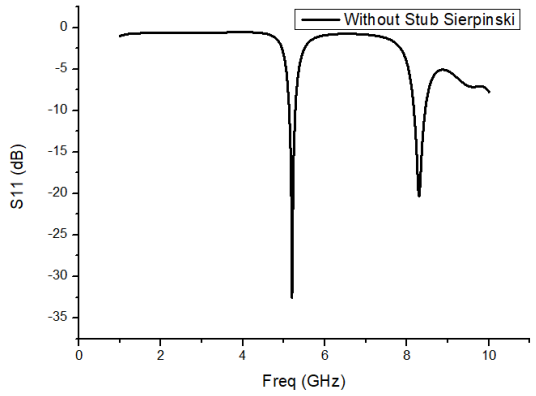
Fig 5: Sierpinski Carpet Fractal antenna with parameters

3. Results

These antennas are designed for the application of WLAN at 5.2GHz.Results show that the 2nd iterations of these antennas are well suited for this application. Return loss of the cantor fractal antenna at its 2nd iteration is -30dB which is revealed in Figure 6. (a). Figure 6. (b) is the return loss of the Sierpinski Carper antenna at its 2nd iteration which is at -32dB



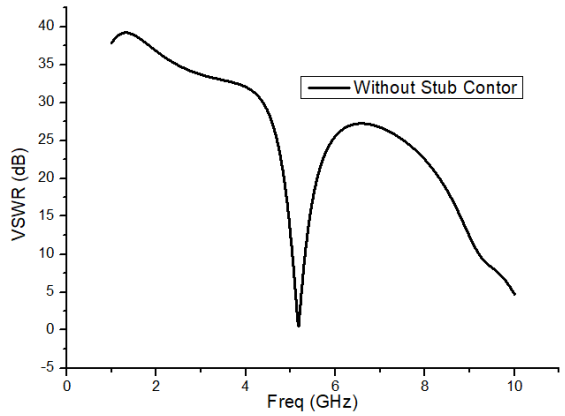
(a)



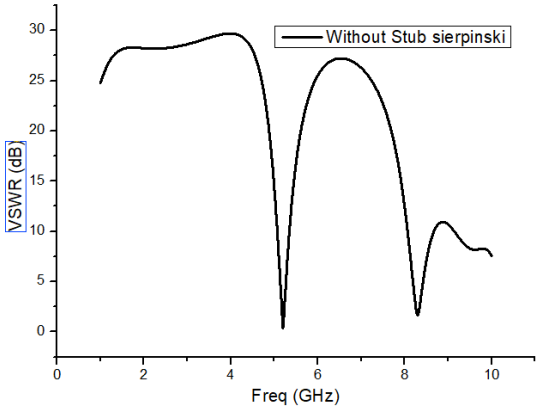
(b)

Fig 6. Return loss plot (a) Cantor Fractal Antenna (b) Sierpinski Carpet Fractal at its 2nd Iteration

The VSWR value of any antenna should be as low as possible to reduce standing waves.VSWR value obtained for iteration 3 of the cantor fractal was 0.54dB and for the Sierpinski carpet, it was 0.4dB only. These are shown in Fig 7. (a) & (b)



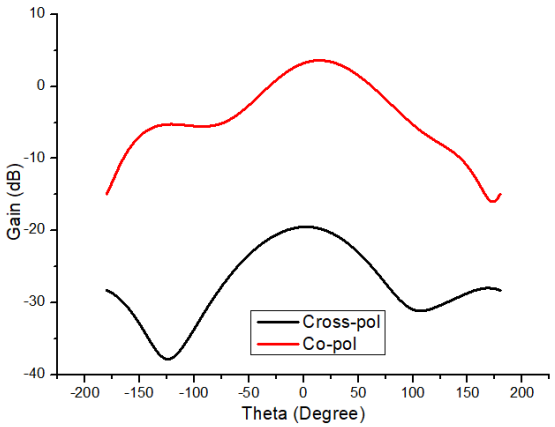
(a)



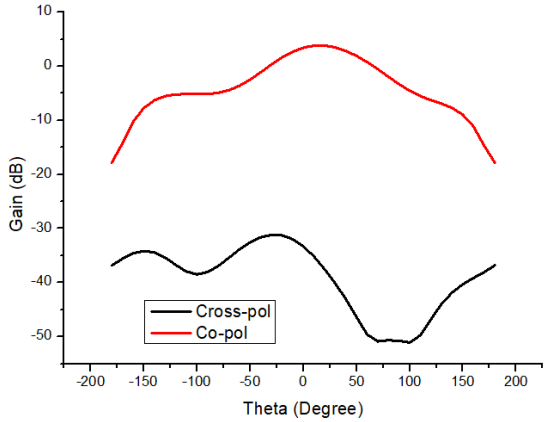
(b)

Fig 7. VSWR plot (a) Contor Fractal Antenna (b) Sierpinski Carpet Fractal at its 2nd Iteration

Cross polarization is the radiation in unwanted directions. So this must be very minimum for a good antenna. Cross polarization of Cantor Fractal antenna & Sierpinski without stub is -19.49dB & -33.3dB Resp.



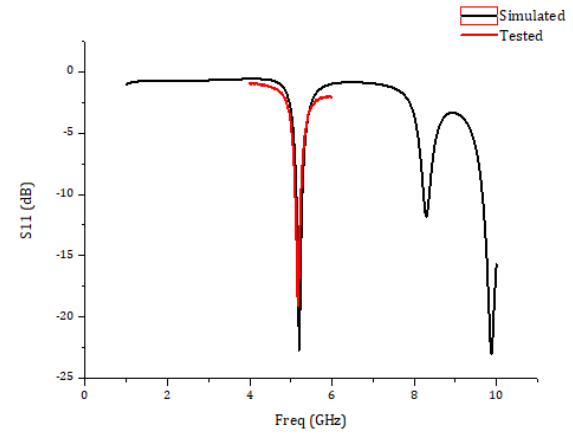
(a)



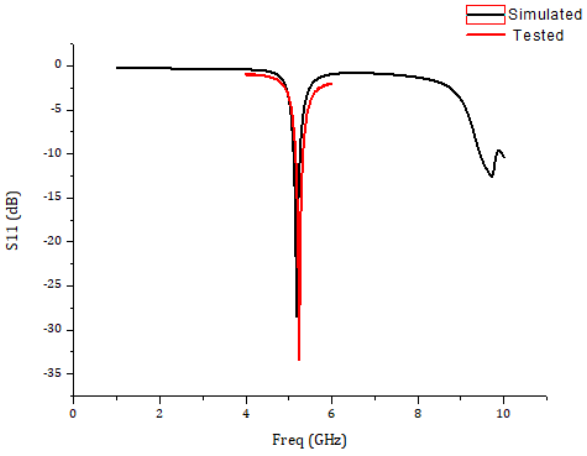
(b)

Fig 8. Co & Cross Polarization Plots (a) Cantor Fractal Antenna (b) Sierpinski Carpet Fractal at its 2nd Iteration without Stub

The Return loss of Cantor & Sierpinski antennas with stub added at its matching line are -20.4 dB & 35 dB with VSWR values of 0.65dB & 1.27dB resp.

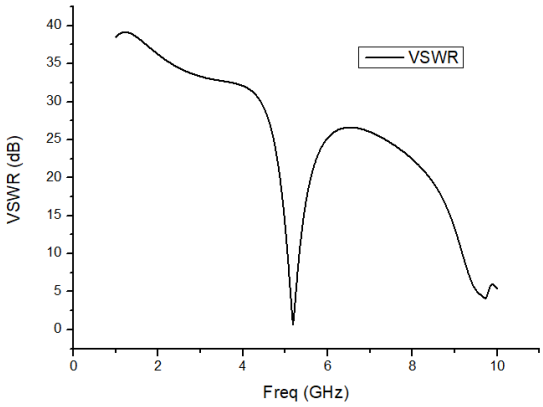


(a)

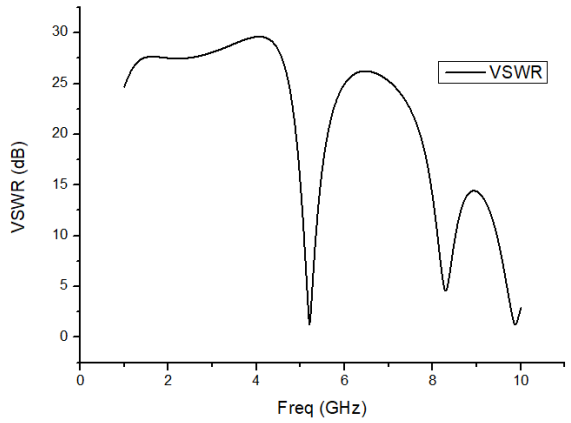


(b)

Fig 9. Tested and Simulated Return loss plot with Stubs Added at Matching line (a) Cantor Fractal Antenna (b) Sierpinski Carpet Fractal at its 2nd Iteration



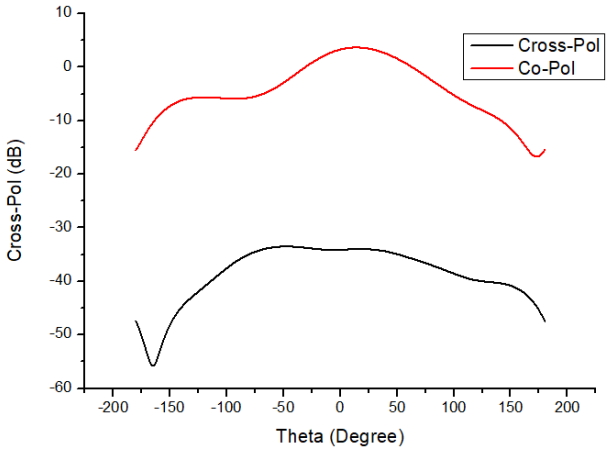
(a)



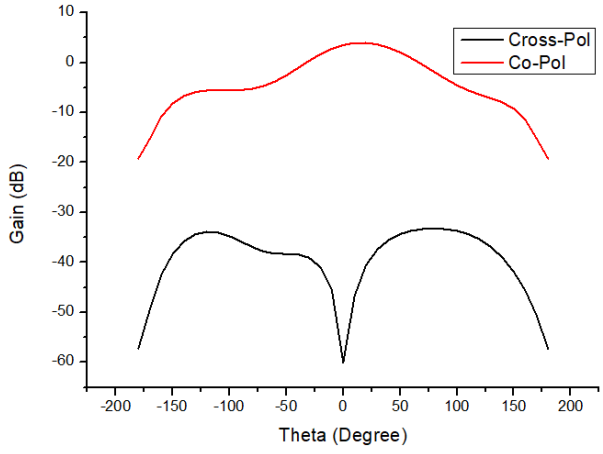
(b)

Fig 10. VSWR plot with Stubs Added at Matching line (a) Cantor Fractal Antenna (b) Sierpinski Carpet Fractal at its 2nd Iteration

With the addition of Stubs, the Cross polarization has been improved drastically. The Cross-pol of Cantor became -34db & that of Sierpinski improved to -60dB



(a)



(b)

Fig 11. Co & Cross Polarization Plots (a) Cantor Fractal Antenna

(b) Sierpinski Carpet Fractal at its 2nd Iteration with Stub

4. Conclusion

Fractal Antennas that can be used for HiperLAN Application (At 5.2GHz) with Minimized Cross polarization is presented here. To reduce the cross-polarization; stubs have been incorporated in the matching line. Cross-polarization minimization up to -60dB could be achieved by using this method. So these antennas have good polarization purity and are a good candidate for HiperLAN

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