# Stacked Multiband Fractal Patch Antennas

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## 1. Introduction

Since the first fractal antenna was introduced, fractal geometries have been applied to the design of antennas especially for multiband antennas because of its self-similarity. In [1] - [3], the Sierpinski triangle gasket is used to make multiband monopole and dipole antennas. In [4], the Sierpinski carpet geometry is applied for the first time to the geometry of a square microstrip patch antenna to obtain multiband frequency operation. As a result, three different frequency bands have been obtained at 1.5GHz, 4.5GHz and 13.5GHz. However at 13.5GHz very narrow bandwidth (13.56GHz – 13.63GHz) and poor input impedance (29.14 + j1.59 ohms) are observed.

In this work, the Sierpinski carpet microstrip patch is modified by stacking iterations to achieve multiband frequency operation and miniaturization.

## 2. Antenna Design and Configuration

A schematic diagram of the square microstrip fractal patch antennas is in Figure 1. In this work, to obtain three different multiband frequency operations, three different sizes of printed square patches are printed on the two layers of the dielectric material. At the bottom layer, one 65.33 x 65.33 mm square patch is printed as Figure 1(a) and at the top layer one 21.78 x 21.78 mm and eight 7.26 x 7.26 mm square patches are printed as Figure 1(b). This is 1/9 the area of the multiband fractal patch antenna in [4]. As a substrate, copper clad 62mil thickness of Rogers RT – Duroid 5880 ($\varepsilon_r = 2.2$) is used.

Iteration 1 square patch is printed on the lower substrate and iteration 2 and 3 square patches are printed on the upper substrate. The details of the design are shown in Figure 1. The iteration 1 square patch printed on the lower substrate is fed by probe at 50 ohms input impedance point where is 22.86mm from the

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edge of the patch. Iteration 2 and 3 patches on the upper substrate are fed by electromagnetic coupling from the lower patch.

Lower and upper layer of the substrates are connected with four nylon screws. All patch antennas are fabricated and measured at the SIUC Antennas and Propagation laboratory.

## 3. Results

Measured return loss for the three different operating bands are shown in Figure 2. The bandwidths (VSWR < 2) are also measured for each frequency band. The details are summarized in Table 1 with input impedance at the lowest return loss point. It can be seen that for the first and second bands, the bandwidths are very close to the results in [4]. However, for the third band, the bandwidth in this work (2.76%) is broader than the bandwidth in [4] (0.5%).

| Resonant frequency (GHz) | VSWR < 2 (GHz) | Zin at fr (Ohms) |
|---|---|---|
| 1.49 | 1.485 – 1.5 | 46.3 + j 8.24 |
| 4.46 | 4.41 – 4.505 | 51.7 – j 1.2 |
| 13.56 | 13.41 – 13.785 | 46.3 + j 8.24 |

Table 1. Bandwidths and input impedances at the resosnant frequencies.

Radiation patterns in all three bands are simulated using a Finite Difference Time Domain (FDTD) software CONCERTO from Vector Fields Inc. [5]. Figure 3 shows co-polarization and cross-polarization of the E-plane and H-plane for the first band (1.43GHz). Due to the geometrical asymmetry of the iteration 3 (7.26mm x 7.26mm) antennas in the E-plane with respect to the feed point location, multiple lobes of the E-plane radiation pattern are observed in band 3.

## 4. Conclusion

Here we have introduced the stacked microstrip patch antennas using the Sierpinski carpet geometry for multiband frequency operation. Three different sizes of the square patch antennas are constructed on the two different substrates and carefully aligned. The measured return loss shows good impedance matching characteristics in all three bands and simulated radiation patterns are similar to the results in [4]. This proposed design achieves the same three operating bands and even broader bandwidth at the third band with much smaller size than the fractal antenna in [4] in both the size (only 1/9) and number of the elements.

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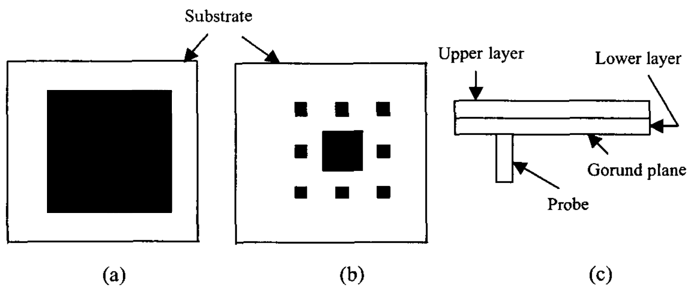
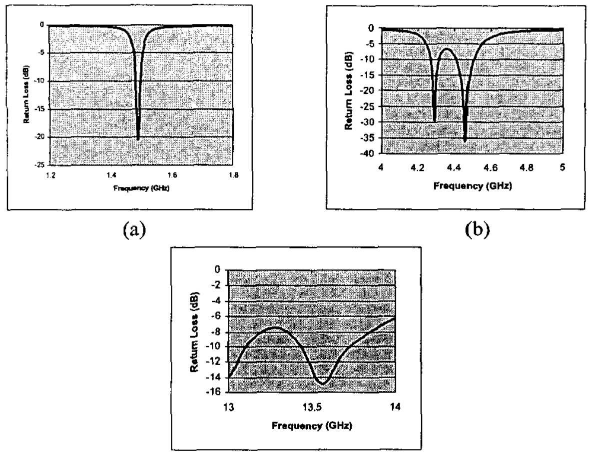
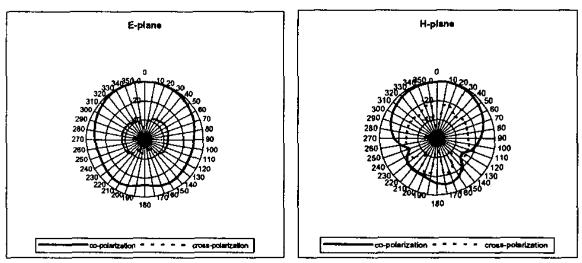



Figure 1. Antenna configuration. (a) Lower layer, (b) Upper layer, and (c) Side view.




(a) (b) (c)

Figure 2. Return losses at the three different frequency bands. (a) first band (1.5GHz), (b) second band (4.5GHz), and (c) third band (13.5GHz).




(a) (b)

Figure 3. Radiation pattern at the first band (1.5GHz). (a) E-plane co and cross-polarization, and (b) H-plane co and cross-polarization.