A New Dual Band Antenna with Hexagonal Carpet in Ground Plane

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***Abstract*— In this paper a new hexagonal shaped patch with modified hexagonal carpet ground plane antenna is proposed. The design is obtained by using EM Simulation Software. Its structure is based on carpet fractal geometry introduced in ground plane. The resonance frequency of a conventional hexagonal patch with full ground is lowered by removing carpet of hexagonal elements from the full ground plane. The antenna is optimized for a dual band operation. This dual band antenna delivers a return loss better than 25dB and gain of 4.88dBi and 5.71dBi at 3.176GHz and 4.552GHz, respectively. The proposed antenna shows a broadside radiation pattern in agreement with the conventional patch antennas.**

***Keywords* – fractal; carpet; dual-band; resonant frequency; broadside.**

I. INTRODUCTION

The dramatic developments of a variety of wireless applications have remarkably increased the demand of multiband/wideband antennas with smaller dimensions than conventionally possible. This has initiated antenna research in various directions, one of which is by using fractal shaped antenna element [1]. There is an important relation between antenna dimensions and wavelength. This relation states if antenna size less than $\lambda/2$ then antenna is not efficient radiator because radiation resistance, gain and bandwidth is reduced. This is because as size of antenna reduces, mismatch between antenna and source increases. Fractal geometry is a very good solution for this problem.

A fractal is a self-repetitive curve whose different parts are scaled copies of the whole geometry. Consequently, a radiator based on a fractal or self-similar geometry is expected to operate similarly at multiple wavelengths [2, 4] and might keep similar radiation parameters through several bands. A multiband operation, in the 1-10GHz frequency range, was attained in [3] through the use of the Sierpinski gasket fractal. Key benefits of fractal antennas are reduced size and compactness. Fractals have space-filling property which leads to curves that are electrically very long, but fit into compact physical space. This property leads to the miniaturization of antenna elements. There are a variety of fractal shapes, such as Hilbert Curve [5], Sierpinski-carpet [6], Minkowski [7], Koch curve [8] etc.

In this paper a new hexagonal shaped patch with modified hexagonal carpet ground plane antenna is suggested. This paper includes a design section which describes the structure of the antenna. The effects of removing hexagonal carpet in ground plane are discussed in the following section. Simulated radiation characteristics and the peak gain of the proposed antenna for both bands are also discussed. A few conclusions are made in last section.

II. ANTENNA DESIGN

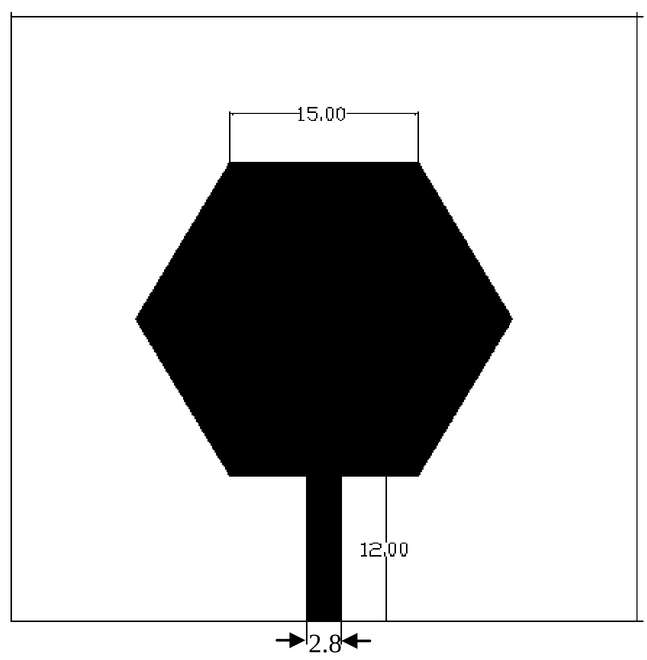


Fig. 1 Geometry of the radiating element with full ground plane

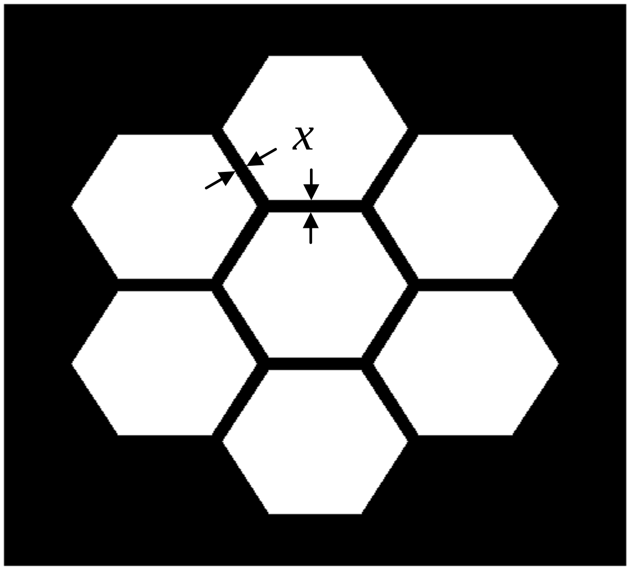


Fig. 2 The ground plane with removed hexagonal carpet

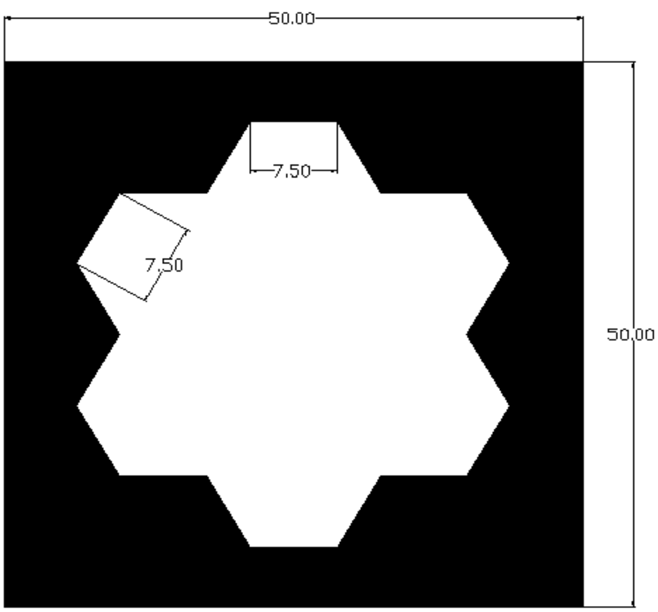


Fig 3. The ground plane (at *x*=0) of dual band antenna

The proposed antenna consists of a 50-ohm micro-strip line fed hexagonal patch element mounted on a dielectric layer over a ground plane. The low cost fiberglass dielectric substrate FR-4 is used having 1.6 mm of height and a relative permittivity of 4.4.

The proposed antenna has compact size of 50×50mm^2. The radiating element is designed by taking a patch in hexagon shape of edge length 15mm with full ground plane. Later a carpet of hexagons is removed from the ground plane. The scaling factor for the carpet elements is taken as half of the hexagonal patch. The central element of the carpet is concentric with the patch while other elements are placed around its edges forming hexagonal carpet geometry. The surrounding elements are placed at a gap (*x*) from the central element. Parametric study for *x* has been done.

III. Antenna Characteristics

The proposed antenna is simulated and optimized by using full wave EM simulation software. The simulated return loss against frequency for the proposed antenna is shown in Fig. 4.

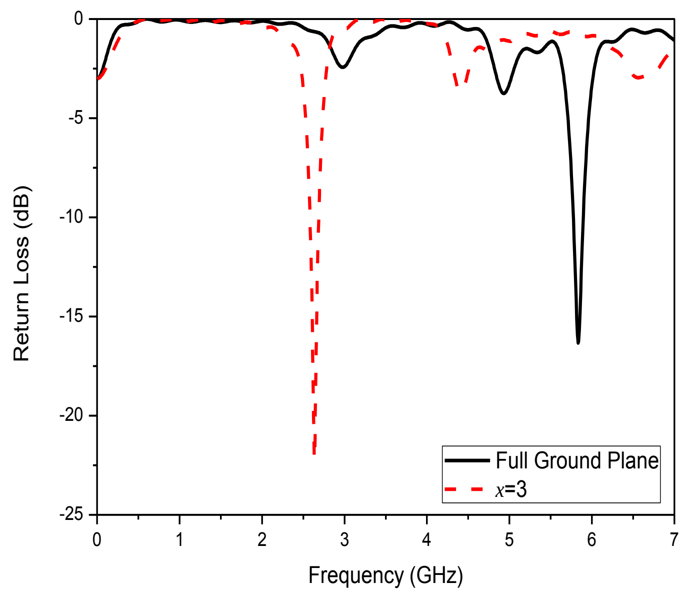


Fig. 4 Return loss variation with full and modified ground plane

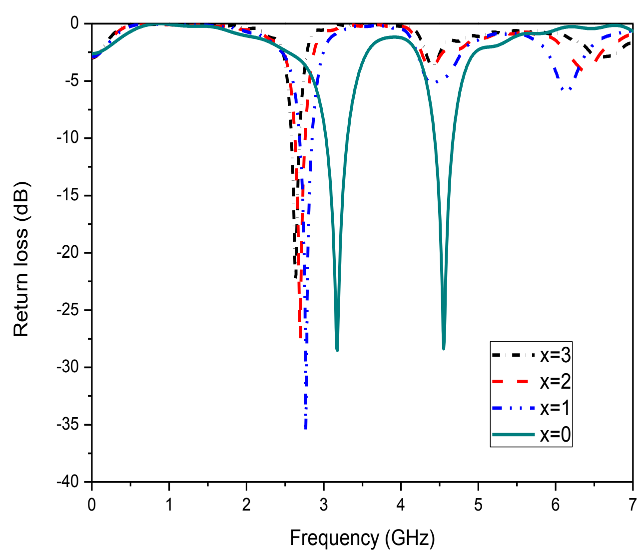


Fig. 5 Return loss variation with gap(*x*)

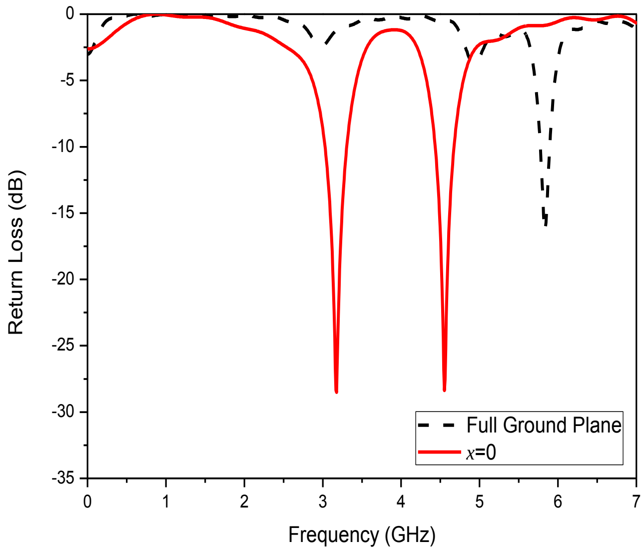
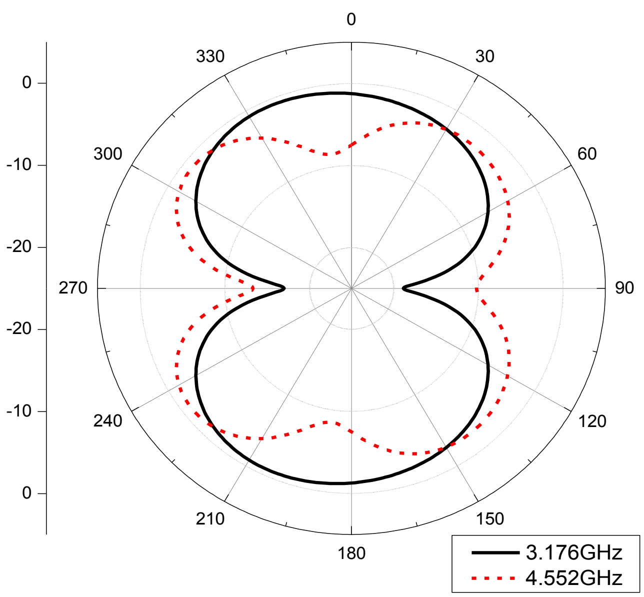
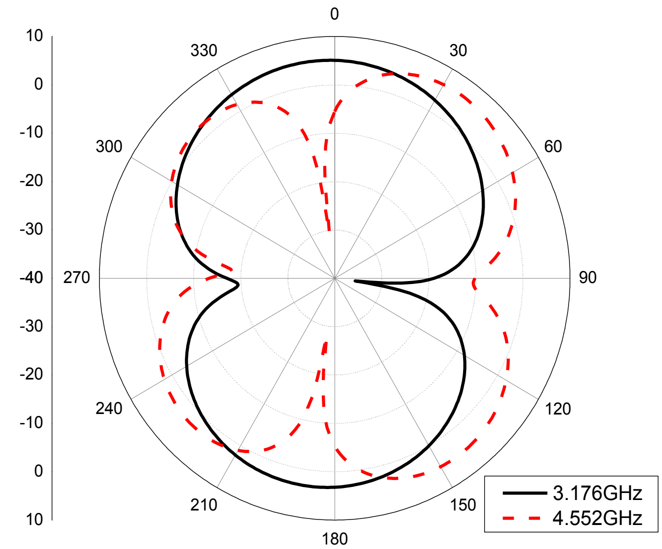


Fig. 6 Return loss of final antenna at *x*=0

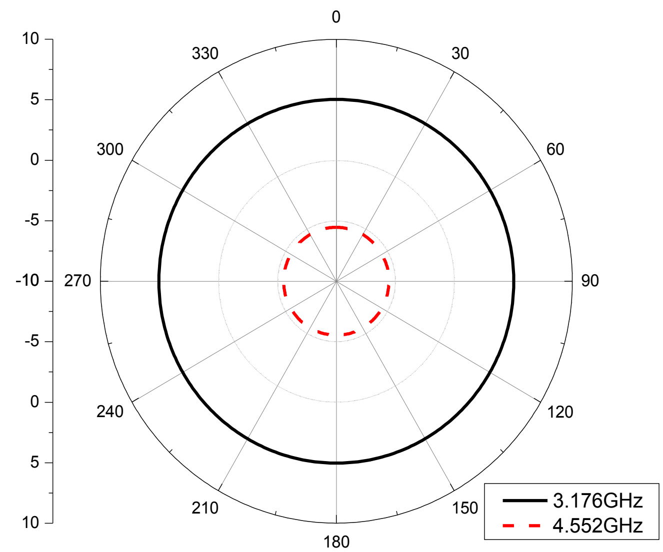
For this figure the resonance frequency of a conventional hexagonal patch with full ground is lowered by removing carpet of hexagonal elements from the full ground plane. Initially a hexagonal patch microstrip antenna is designed at 5.8GHz, then after removing a hexagonal carpet fractal from the ground plane and by keeping the surrounding element at a gap of *x*=3, the antenna resonates at 2.632GHz i.e. a reduction of 55% in resonating frequency is achieved by using carpet fractal in ground plane.



(a)



(b)



(c)

Fig. 8 E field pattern in (a) xz plane (b) yz plane (c) xy plane

Further, the resonance frequency vs. gap (*x*) is simulated and shown in Fig. 5, and found that the resonating frequency is slightly increasing with falling x and a new resonating band is observed for *x*=0, depicting a dual band characteristic. The antenna is optimized for a dual band operation. This dual band antenna delivers a return loss better than 25dB and gain of 4.88dBi and 5.71dBi at 3.176GHz and 4.552GHz, respectively. Table I summarizes the key parameters of the proposed dual band antenna.

TABLE I

PERFORMANCE OF DUAL BAND ANTENNA

Frequency (GHz)	3.176	4.552
Return loss (dB)	-28.51	-28.38
Bandwidth (%)	8.7	5.3
Gain (dBi)	4.88	5.71
Directivity (dBi)	5.08	6.41

IV. CONCLUSION

A new hexagonal shaped patch with modified hexagonal carpet ground plane antenna is designed and presented. Carpet fractal geometry is introduced to lower the resonant frequency. The resonance frequency of a conventional hexagonal patch with full ground is lowered by removing carpet of hexagonal elements from the full ground plane while maintaining the good radiation characteristics. A dual band characteristic is obtained by optimizing the gap (*x*). This optimized antenna is having a good gain at both the resonating frequency. The proposed antenna shows a radiation pattern that is broadside in E-plane and Omni-directional in H-plane which is in agreement to the conventional patch antennas.

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