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# High Performance Circularly Polarized Antenna Based on Fractal EBG Structure

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## INTRODUCTION

Circularly polarized patch antennas have been widely applied in wireless communication system, global positioning system, etc., because of their low-profile, lightweight, ease of fabrication and low lost [1,2]. To achieve high performance for circularly polarized patch antennas, some new structures were reported in the literature, such as antennas array, stack layer antennas, using periodic structures [3-7], etc.

In this paper, a high performance circularly polarized low frequency patch antenna based on the compact fractal high-impedance surface EBG structure has been fabricated and experimented. The measured results show that the proposed circularly polarized patch antenna has good performance in impedance bandwidth, axial ratio (AR) bandwidth, and gain.

## THE NOVEL EBG CIRCULARLY POLARIZED ANTENNA DESIGN

A fractal structure is applied on the hi-impedance surface structure in order to reduce the size of EBG cell. The fractal cell is provided using the Minkowski loop generator. The initial shape is the square patch of side A ($0^{th}$ iteration). For the $1^{st}$ and $2^{rd}$ iteration, each side is replaced with new scaled generator (A1=A/3; B1=0.5*A1, A2=A1/3, B2=0.5*A2), where A1, A2 and B1, B2 are segment and indentation lengths, respectively (Fig.1). The period of the proposed EBG structure is 32.5mm, and A=27mm. A fractal patch connected to the continuous ground plane through a shorting pin constitutes a unit of the lattice. The radius of the shorting pin is 0.5mm.

The dispersion characteristics of the fractal Hi-Impedance Surface EBG structure is calculated using the Finite Element Method (FEM). The results illustrated in Fig.2 show a wide bandgap from 1.27GHz to 2.05GHz.

A square patch antenna with truncated opposite corners is designed as Fig.3, which excites both the $TM_{01}$ and $TM_{10}$ orthogonal modes, can produce circularly polarized fields. The square patch antenna size is $56.0\times56.0m^2$, which have two opposite truncated corners with a side length of 2.8mm. The feed point is offset from the centre point of the square patch by 9.35 mm. The substrate used is FR4, which has a dielectric constant $\varepsilon_r$ =4.4, the thickness $h$=3.04mm and the ground plane size is 130mm$\times$130mm. In general, because of the surface wave, the gain of the conventional patch antenna on a high permittivity substrate is low and the bandwidth is very narrow. In this paper, a novel circularly polarized antenna with a fractal EBG structure is presented. This fractal high impedance surface EBG structure is proposed because of its compact size and wide bandwidth features. The performance of this patch antenna is thus improved with the help of EBG structures.

## THE MEASUREMENTS

Fig.4 and Fig.5 show the return loss and the Smith chart for the proposed circularly polarized antennas, respectively,

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which illustrates an impedance bandwidth from 1660 to1712MHz below 10 dB. The measured axial ratio in the broadside direction against frequency is shown in Fig.6, which axial ratio bandwidth is from 1.678 to 1.705MHz. The measurement results show the centre frequency 1.695GHz has a minimum axial ratio, about 0.80dB. The XoZ plane and YoZ plane's radiation patterns at 1.695GHz are shown in Fig.7. This illustrates a good axial ratio in the upper half-plane. The measured gain for the proposed EBG antenna is 7.0dB at 1.695GHz.

## CONCLUSIONS

A circularly polarized patch antenna with a compact fractal electromagnetic bandgap structure substrate is fabricated and experimented. It provides circular polarization with a good axial ratio (AR) within a reasonably wide bandwidth. A significant gain improvement is achieved and the axial ratio is very low in the upper half-plane.


## ACKNOWLEDGEMENTS

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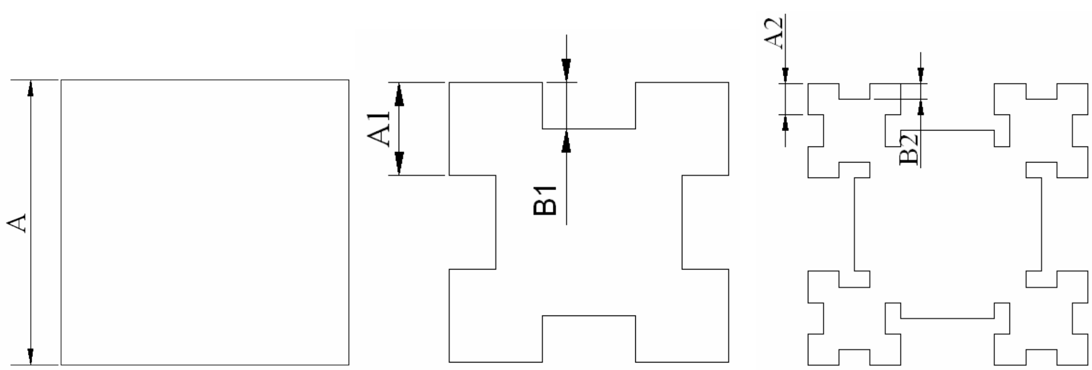



(1) o$^{th}$ iteration (2) 1$^{st}$ iteration (3) 2$^{rd}$ iteration

Fig.1 The scheme of the fractal hi-impedance structure

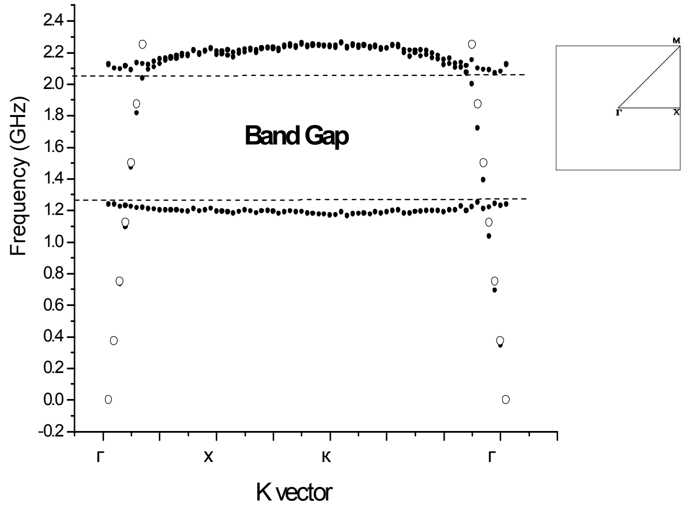
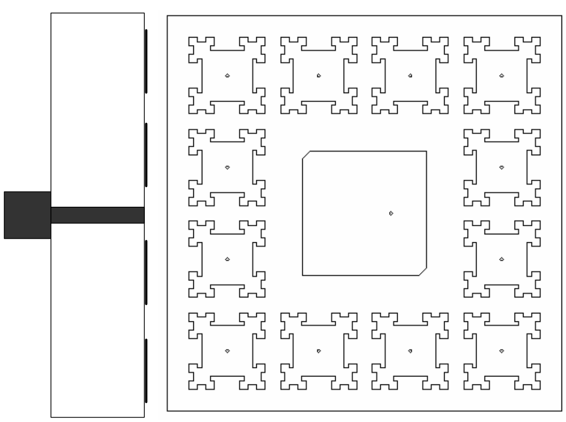



Fig.2 Simulation results for the dispersion curve of two-layer fractal EBG structure



(a) profile (b) top layer

Fig.3 The Geometries of Circularly Polarized Antennas with Fractal EBG structure

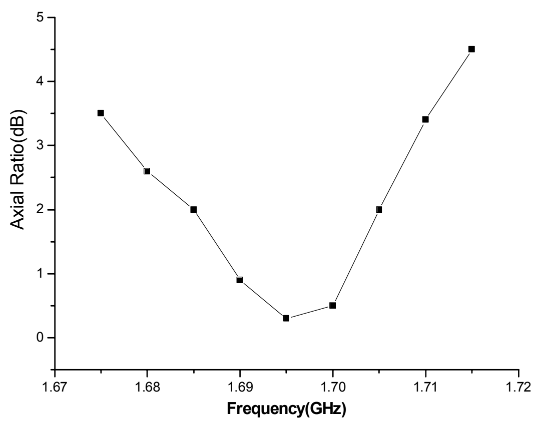
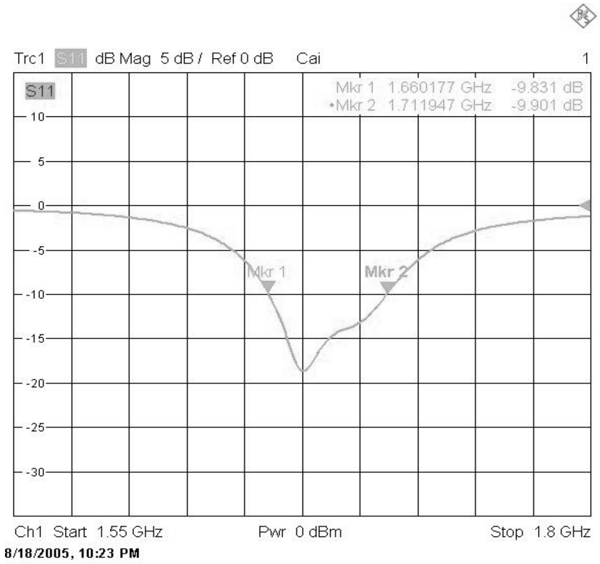



Fig.6 The measurement of the axial ratio for the proposed circularly antennas



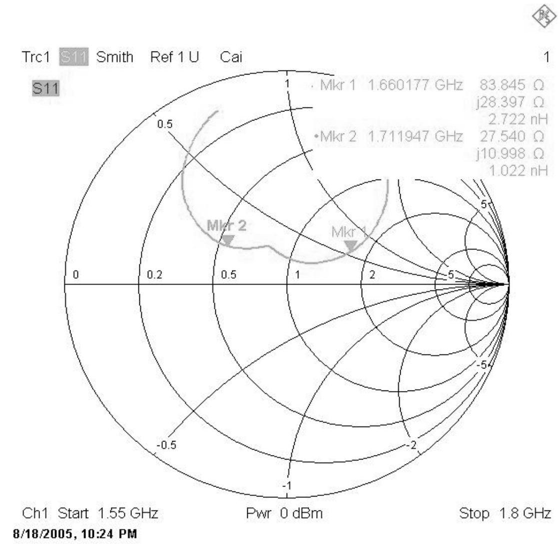
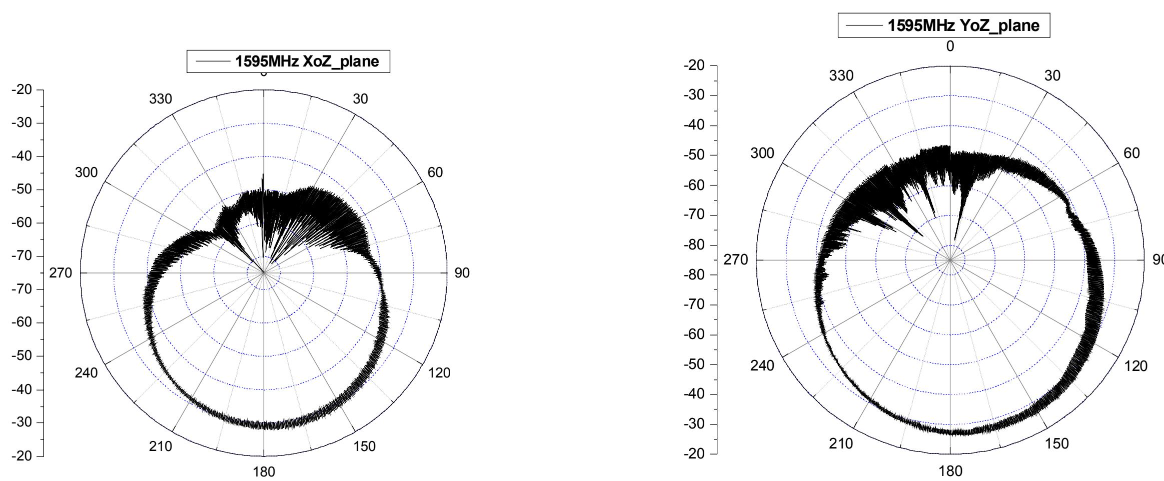




Fig.4 The return loss for the circularly polarized antennas

Fig.5 The smith chart for the circularly polarized antennas




(a) XoZ plane

(b) YoZ plane

Fig.7 The spinning radiation patterns for the proposed antennas