A Single Feed Circularly Polarized RFID Reader Antenna with Fractal Boundary

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***Abstract-* A single feed circularly polarized RFID reader antenna with Minkowski fractal boundary is proposed. A 2-itration Minkowski patch is adopted for antenna compactness and four rectangular slots are etched on the ground to improve the antenna performance. The simulation result shows that this antenna behaves good characteristics in the design band，which has a -10dB impedance bandwidth of 52MHz(906-958MHz),3dB (Axial Ratio)AR bandwidth of 12MHz(917-929MHz). This design shows that the antenna structure is simple, easy for manufacture and integration.**

Index terms – circularly polarized, fractal, RFID , reader antenna , slot

I. INTRODUCTION

In recent years, radio frequency identification (RFID) technique is widely used in the logistic, distribution market, merchant flow tacking and other areas. The RFID reader antenna, which is the critical component in the RFID reader system, has been thoroughly investigated. Generally, the tag antennas are arbitrarily oriented. So it's advisable that a circularly polarized reader antenna is needed for reliable detection. Microstrip patch antenna have many advantages with low profile, low cost, easy fabrication and easy to realize dual-frequency and circular polarization [1]. These properties make compact microstrip very popular and attractive for RFID and wireless communication system.

The "fractal" concept was first proposed by B. Mandelbrot in 1975 [2]. Most fractal objects have self-similar shapes and space filling ability. This property can achieve antenna miniaturization and band improvement. Fractal theory has been widely used in antenna design. Monopole antenna and fractal loop antenna have achieved remarkable progress in reducing antenna's size [3] [4]. A wideband Minkowski fractal dielectric resonator antenna is proposed. Parametric study is carried out to investigate the antenna design [5]. By replacing each side of square patch with Koch curve of 2nd stage and having fractal slot of same indentation angle but scaled down in the centre of the radiation patch, the proposed antenna get 1.2% 3dB AR bandwidth[6],but this antenna have a big slot dimensions sensibility, this would increase the difficulty of fabrication.

In this paper, we propose a compact, circularly polarized mircostrip RFID reader antenna based on Minkowski structure. The antenna is fed by coaxial probe along the patch diagonal axes. The antenna can achieve circularly polarized radiation by trimming resonance length. Because of folding boundary of fractal, the gain and radiant efficiency of dominant mode decrease. For compensation of the antenna radiation pattern, four identical rectangular slots are etched on the ground for lower the dielectric constant of the antenna equivalently [7].

II. DESIGN OF ANTENNAWIHT MINKOWSKI FRACTAL BOUNDARY

The generation of Minkowski fractal patch

The construction of many ideal fractal shapes is usually carried out on initiator by applying an infinite number of times (iterations). The iteration determine the inner structure of the fractal graph. The initiator and iteration of the Minkowski fractal curve are depicted in Fig. 1. Suppose that the initiator length is L, displace the middle one-third of each straight segment by the fold line. Indentation factor ρ is defined here as the ratio of indentation width to the indentation length of the fold line. Changing the indentation factor causes a shift in the resonant frequencies, we can get different 1st Minkowski fractal curve.

The Minkowski fractal patch can be obtained by replacing each side of square patch by Minkowski fractal curve of 2nd stage. The generation procedure for the patch with Minkowski

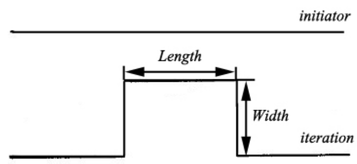


Fig.1. initiator and iteration of the Minkowski fractal curve

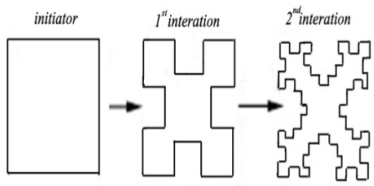
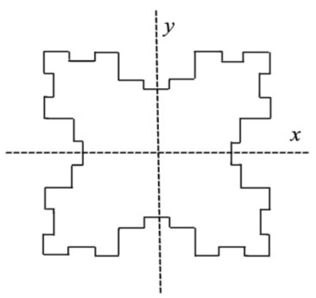


Fig.2 . Generation procedure for the patch with Minkowski fractal boundary

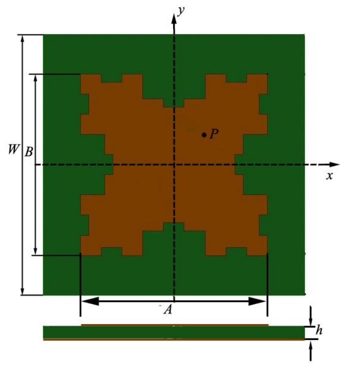
fractal boundary is depicted in Fig. 2. The N order patch antenna with ideal Minkowski boundary can be achieved by N order iteration, but it is impossible to get an infinite fractal structure along with increasing the difficulty of fabrication and appearance of more high order mode which lead to decrease of the antenna radiant efficiency. This paper discussed the compact microstrip antenna based second order Minkowski fractal boundary.

The structure of Minkowski fractal patch antenna

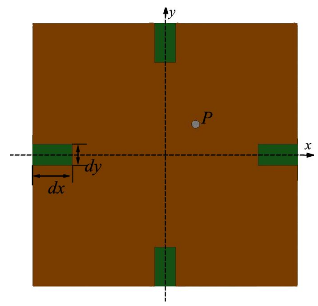
The configuration of the proposed antenna is depicted in Fig.3. The antenna is designed on a FR4 substrate (thickness h=5mm, dielectric constant=4.4 and loss tangent=0.02). The mode TM_{01} and TM_{10} are excited when the microstrip antenna is fed by a coaxial probe along the diagonal line. The two modes will have the same frequency, amplitude and phase if the length of the patch equals the width. The two orthogonal modes, which have the same amplitude and phase difference of 90 degrees, are obtained by trimming resonance length. On the basis of microstrip fundamental theory, the simulation results are studied by using the commercial FEM solver Ansoft HFSS. The coaxial-feed location is on the diagonal with a coordinate of (x0=y0=11mm). The length(A) and the width(B) of the rectangular patch are 69.5mm and 72mm respectively. The ground-plane area of the antenna(100mm×100mm), which is selected based on suitability for common RFID reader applications. Fig.4. shows the reflection coefficient characteristics when the indentation factor ρ is varied. It can be seen that with an increase of ρ the frequency keeps decreasing, which is due to the bend of the current 's electrical length, hence a decrease in the patch dimension. But it also causes the drop of the antenna's gain and radiant efficiency. On synthesizing this contradictory condition, we choice ρ =0.35. To further compensate the gain and radiant efficiency, four rectangular slots with each of size (15mm×8mm) are etched on the ground plane and they are symmetrically located on the y-axis and x-axis. This configuration is exactly symmetrical with little influence on the antenna radiation pattern. However, the slots change the dielectric constant of the substrate to a certain extent, which lead to the increasing of the antenna radiation efficiency.



(a)



（b）



（c）

Fig.3. geometry of proposed antenna (a)the patch element(ρ =0.35) (b) top view and the side view（P is the feed point） (c) view from the groud-plane side

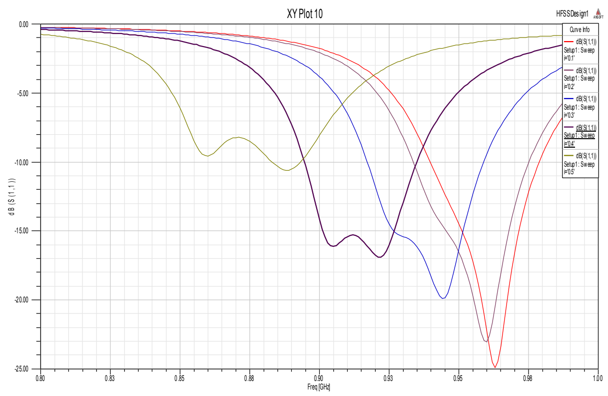


Fig.4.Simulated S11(dB) for different indentation factor

III. NUMERICAL RESULTS

With the ground slots, the impedance bandwidth, for 10 dB return loss, is 52MHz，ranging from 906MHz to 958MHz , as plotted in Fig. 5. It can also be observed that the antenna has broader bandwidth than that without the ground slots. The axial ratio and gain of the propose antenna with and without ground slots are shown in Figs.5 and 6. It is shown that the 3dB bandwidth with ground slots is 12MHz (from 917MHz to 929MHz) with minimum axial ratio of 0.21 dB. And the peak

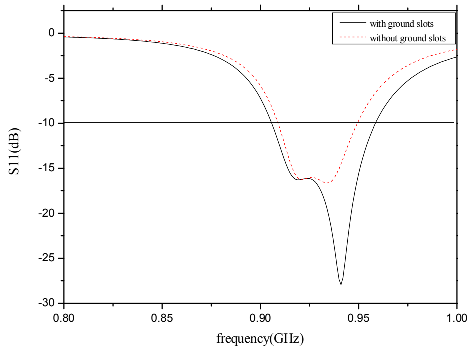


Fig. 5.Return loss of the proposed antenna with and without ground slots

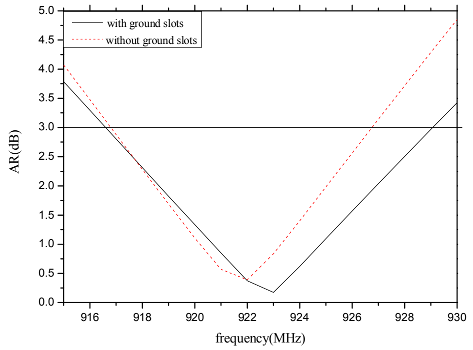


Fig.6.Axial-ratio of the proposed antenna with and without ground slots

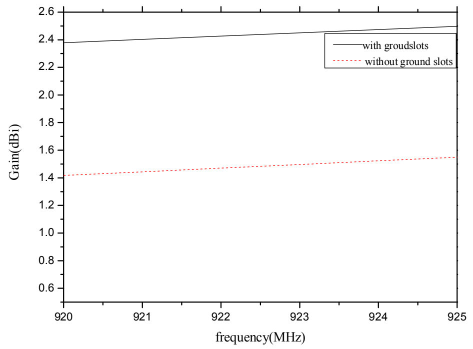


Fig.7. Gain of the antenna with and without ground slots

gain of this condition is from 2.38dBi to 2.49dBi in the UHF band (920 - 925MHz), which is compared to the status of that without ground slots. Approximately 1 dB increase in the peak gain and better AR behavior are obtained.

IV. CONCLUSION

A compact circularly polarized patch antenna with Minkowski fractal boundary is presented for UHF RFID applications. By etching four rectangular ground slots, the impedance bandwidth, 3dB AR bandwidth and the gain of proposed design have some degree of enhancement. Final simulated results show that this antenna has good performance in the band of 920-925MHz(the UHF RFID band in China). And this design has the characteristic of simplicity, low cost, easy to fabricate and useful for integration and array designs.

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