Design And Analysis Of Compact Circularly Polarized Fractal boundaray Circuar patch antenna for Wi-Max Applications

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Abstract - *In this paper, a circularly polarized asymmetric fractal boundary, a compact patch antenna with low axial ratio dedicated for Wireless applications is presented. By replacing the sides of a circular patch with asymmetrical prefractal curves, two orthogonal modes are excited for CP operation. A proposed of the antenna has been design with a 1.6 mm thick single layer FR4 substrate with a relative permittivity of 4.4. The simulated 3-dB axial ratio (AR) bandwidth of the proposed antenna is 120 MHz (3.56–3.68 GHz) and a 10-dB return loss bandwidth is 160.0 MHz (3.51–3.67 GHz) with a gain of 5.7 dB. The overall size of the antenna is 40mm*40mm*1.6mm. In addition, comparison of rectangular fractal boundary and circular fractal boundary improve more bandwidth are examined and discussed in detail. All the simulations results are carry out using HFSS software package and Simulation results are given, indicating that this S band antenna realizes the required satellite specifications in terms of frequency bandwidth, gain, circular polarization bandwidth, and axial ratio (AR) beamwidth*.

Key Words*: *Circular polarization, axial ratio, patch antennas,

Fractal boundary, single probe feed, Wimax communication

1.INTRODUCTION

RECENT developments in the field of wireless communication systems have accelerated the demand for compact circularly polarized microstrip antennas (CPMAs). In order to avoid the misalignment between transmitter and receiver, circularly polarized antennas have been used in a wide range of applications such as Wi-Fi, WiMAX, WLAN, and handheld devices. The conventional approach to achieve circular polarization (CP) involves feeding two orthogonal signals of equal amplitude and 90 out of phase to the radiating and nonradiating edges of a square patch antenna. Despite its high CP bandwidth and best axial ratio (AR) (0 dB), the dual-feed technique requires an external polarizer and occupies a lot of board space. Therefore, single-feed compact CPMAs have received much attention in recent years. The flexibility offered by printing technology also helps in designing various CP antennas with single probe feed.

In 1983, Sharma and Gupta came up with the concept of a single-feed CP antenna by truncating corners and implanting a diagonal slot at the center of the square patch [1]. Later, Iwasaki in 1996 using a proximity-coupled feed suggested cross-shaped slot of unequal arm's length embedded in the middle of the circular patch for CP operation [2]. Asymmetric

cross slot provides the requisite perturbation to excite two

orthogonal modes with 90 phase shift for CP radiation. By inserting four symmetrical slits along the diagonals of the corners truncated patch, CP is realized, and a considerable amount of size reduction is also reported [3]. Asymmetrical U-slot [4], Y-shaped monopole [5] antennas are available in the open literature for CP operation. Based on the slits [6], [7], Fractal concept has significantly affected the micros trip antenna field. Fractals are categorized into mass and boundary fractals. Mass fractals have been used to design antennas for multiband or wideband applications [8], [9].

In this letter, a novel compact CPMA is proposed by using a prefractal curve as boundaries of a circular patch. By effective adjustment of fractal curve, compact CPMAs can be realized.

2. LITERATURE REVIEW

1. **P. C. Sharma and K. C. Gupta, Nov.1983.**

Analysis and optimized design are presented of three types of single feed circularly polarized microstrip antenna , namely, a diagonal fed nearly square, a truncated-corners square and a square with a diagonal slot. The Green's function approach and the de segmentation methods are used. The resonant frequencies are calculated for two orthogonal modes which together yield circular polarization. Optimum feed locations are determined for the best impedance match to a50 \Omega coaxial feed line. Axial-ratio bandwidth, voltage standing wave ratio(VSWR)bandwidths and radiation patterns are evaluated and verified experimentally.

2. **Poongodi C1, Deepa D2, Shanmugam A3**

A compact cross, circular and square shaped slotted microstrip patch antennas are designed for circularly polarized (CP) radiation. The designed antenna is fabricated on RO4003C substrate and measured using Agilent network analyzer. The simulated return loss of this proposed antenna is less than -16dB at 920MHz with a bandwidth of 3MHz which is most suitable for RFID application. The circular polarization radiation pattern and axial ratio parameters are compared for square, circular and cross shaped antennas. The simulated gain is more than 3dBi for all three antennas. A symmetric, cross shaped slot is embedded along one of the diagonal axes of the square patch for CP radiation and antenna size reduction. The overall size of the antenna with CP radiation can be reduced by increasing the perimeter of the symmetric cross-shaped slot within the first patch quadrant of the square patch. The return losses of the measured results are in agreement with simulated results, the measured S parameters and radiation pattern showed that the proposed design is suitable for RFID frequency regions

3. **H. Iwasaki, Oct. 1996**

Compact fractal boundary microstrip antenna is proposed for circular polarization(CP).By replacing the side so far square patch with asymmetrical pre fractal curves, two orthogonal modes are excited olari for CP operation. The structure is asymmetric along the principal axes ( ). The indentation parameter of the fractal boundary curve is optimized to design compact CP antennas. Experimental results show that 10-dB return loss and 3-dB axial-ratio bandwidths of the propose fractal boundary And 2 are 162 and 50MHz, respectively, at operating frequency of around 2540 Mhz. Results show that an excellent CP is achieved with a single probe feed, besides reduction in the antenna size by applying fractal boundary concept. Index Terms—Axial-ratio bandwidth, circular polarization fractal boundary, single probe feed.

4. **Nasimuddin, Senior Member, IEEE, Zhi Ning Chen**

Novel asymmetric-circular shaped slotted microstrip patch antennas with slits are proposed for circularly polarized (CP) radiation and radio frequency identification (RFID) reader applications. A single-feed configuration based asymmetric-circular shaped slotted square microstrip patches are adopted to realize the compact circularly polarized microstrip antennas. The asymmetric-circular shaped slot(s) along the diagonal directions are embedded symmetrically onto a square microstrip patch for CP radiation and small antenna size. The CP radiation can be achieved by slightly asymmetric (unbalanced) patch along the diagonal directions by slot areas. Four symmetric-slits are also embedded symmetrically along the orthogonal directions of the asymmetric-circular shaped slotted patch to further reduce antenna size. The operating frequency of the antenna can be tuned by varying the slit length while keeping the CP radiation unchanged. The measured 3-dB axial-ratio (AR) bandwidth of around 6.0 Mhz with 17.0 MHz impedance bandwidth is achieved for the antenna on a RO4003C substrate. The overall antenna size is at 900 MHz. Index Terms—Circular polarization (CP), circularly polarized antenna, microstrip antenna, radio frequency identification (RFID), slotted patch, UHF3.

3 ANTENNA DESIGN

The prefractal half-circled curve is deployed to accomplish the CP operation. The four sides of a square patch are replaced with a fractal curve of different IFs for CP realization. With the use of asymmetrical fractal curves as edges of a single-feed square patch, it is possible to excite two orthogonal modes with 90 phase shift for CP radiation. IFs of the prefractal curve are used to optimize the antenna for minimum AR, wide AR bandwidth, wide impedance bandwidth, and size reduction. The proposed square patch antenna with IO2 fractal boundary curves is pictured in Fig. 1.

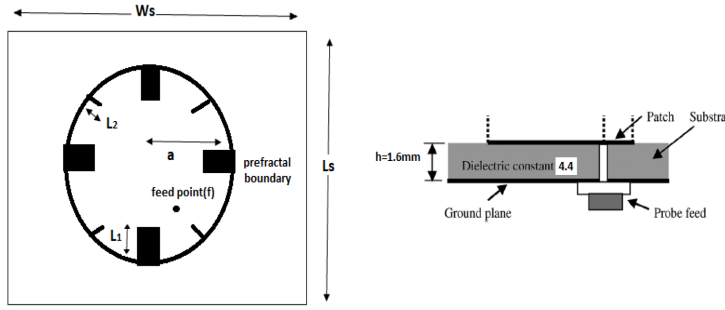

Fig.1 (a) (b)

Figure 1: Generation of proposed compact CP fractal boundary antenna.

(a) TOP View (b) Side View

The dimensions of the strips and the corner of the circular asymmetric slits are optimized to create the resonance and circular polarization at 3.6 GHz. The optimized dimension is as follows: *a*=11 mm, *L1*=3.0 mm, *L2*=1.5mm, *Ls*=40mm, *Ws*=40mm and feed point f=(3.5,3.5,0)

Design Circular Patch antenna Calculations:

1. Calculation Radius of circle (a):

Therefore the resonant frequencies is given by

Formulas used for calculating radius (a) -

$$a = F\left\{1+\frac{2h}{\pi F\varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{-1/2}$$

Where,

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}}$$

After above equations calculation,

We get,

a=10.5mm

2. Calculation of Substrate:

Ls=4a=4x10=40mm

Ws=4a=4x10=40mm

4 RESULTS AND DISCUSSION

The designed fractal boundary asymmetric circular patch patch with rectangular slit was simulated for validate the design. The simulated reflection coefficient of the proposed antenna design is simulated in Ansoft hfss software. Simulated and 10-dB return loss bandwidth are 160 (3.52-3.68GHz)

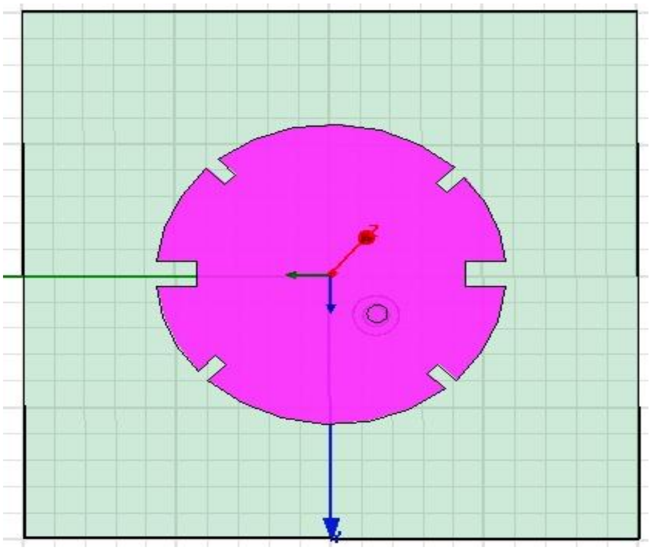

Fig.2 Proposed CP fractal boundary antenna geometry

Fig.3 shows the return loss of the proposed fractal boundary circular patch antenna.it shows that return loss is -21.87 at resonant frequency 3.6 GHz

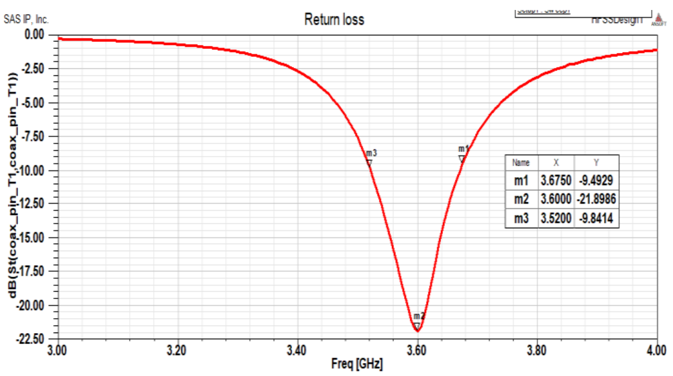

Fig.3 Return loss of proposed antenna

Fig.4 a and b shows the 3-D plot of radiation pattern and polar plot of radiation pattern.it shows the maximum gain of 5.7 dbi.

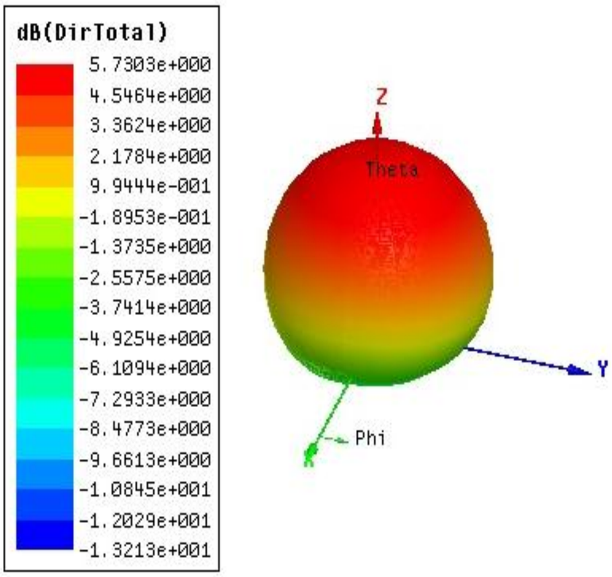

Fig.4 a)3-D plot of radiation pattern

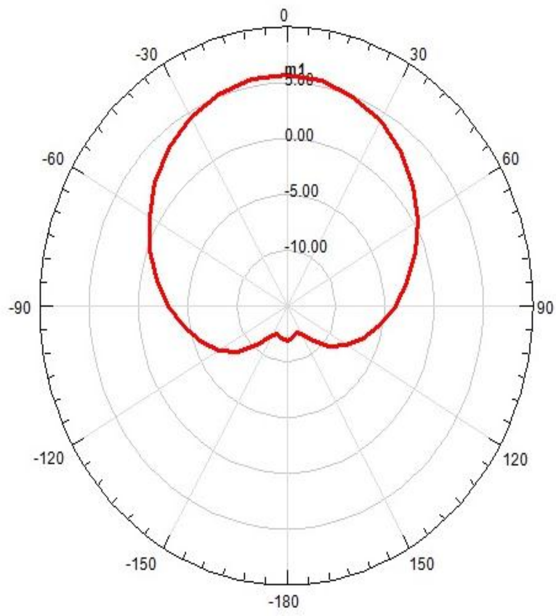

Fig 4.b) Radiation pattern of antenna

Fig.5 shows the VSWR of the antenna.it shows the less than <2 at 3.6 GHz frequency and the fig.6 shows the axial ratio of 0.76db at 3.6 GHz frequency

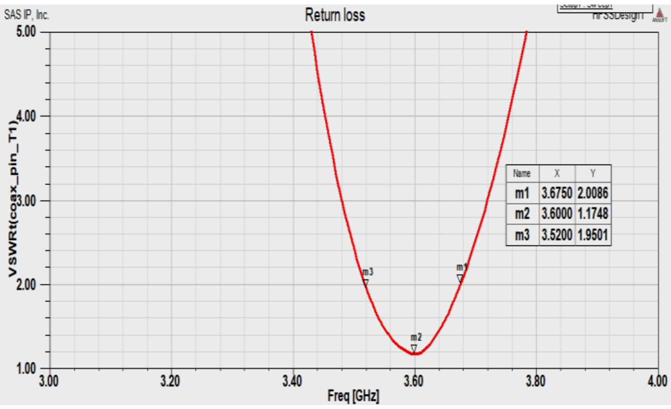

Fig.5.VSWR

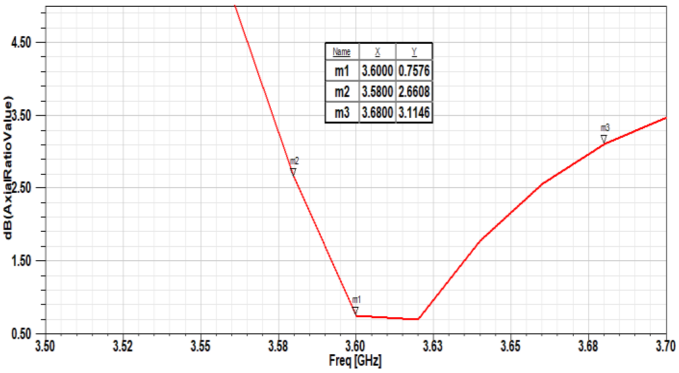

Fig.6 Axial ratio

Figure 6 depicts the simulated AR value is 0.784db at resonant freq of the antenna. The simulated 3-dB AR bandwidth is also near about 120MHz.

In addition, effects of with and without fractal boundary to improve bandwidth are examined and discussed in detail. Table 1shows with bandwidth is increased up to 100MHz instead of 60MHz

5. CONCLUSION

A novel approach to generate circular polarization using boundary fractal has been presented. By introducing perturbation in a square patch using asymmetrical prefractal curves as edges, a single-feed compact circular antenna for CP operation is successfully obtained. Indentation parameter of the proposed prefractal curve is optimized for good CP at the center frequency. Slits are inserted on four corners of the patch. The antenna exhibits an effective bandwidth of 160MHz from 3.52-3.68 GHz for 10-dB return loss and AR<3 dB at 120 MHz. The simulated gain of the antenna is around 5.7 dBi and the 3-dB axial ratio beamwidth is about 180deg. The overall dimension of the antenna is 40mm×40mm×1.6mm at 3.6GHz and thus can be considered as a suitable for various like WI-MAX applications and S-band satellite applications.

Table 1: Comparison table

Sr.No.	Shape of MSA	Freq (GHZ)	Return Loss(dB)	VS WR	BW (MHZ)	Gain (dB)	AR[dB]
1.	RMSA without Fractal boundary patch	3.6	-19.16	1.27	13	3.9	16
2.	RMSA With Fractal Boundary	3.6	-13.86	1.35	12	4.2	2.3
3.	CMSA without Fractal boundary patch	3.6	-18.16	1.28	130	4.4	2.6
4.	CMSA With Fractal Boundary	3.6	-21.89	1.17	155	5.7	0.7

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