Compact Single Feed Circularly Polarized Fractal Boundary Microstrip Antenna

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ABSTRACT

Compact circularly polarized single feed microstrip antenna is presented. The proposed CP antenna uses Koch curve as boundary. It is shown that by using fractal curve as boundary to the square patch the size can be reduced by more than 35 % without much reduction in gain of the antenna. The antenna gives a very good circular polarization with minimum axial ratio very close to 0 dB at the center frequency of 2220 MHz. The antenna provides almost constant gain of about 5.6 dBi over the frequency band of operation.

I. INTRODUCTION

Circularly polarized microstrip antennas find applications in different fields like WLAN, GPS, Mobile satellite, RFID applications etc. It is required to design antennas with compact size without degradation in gain of the antenna in the said applications. The circular polarization can be obtained by exciting two near degenerate modes which are orthogonal to each other. This is achieved by having different lengths in two directions of patch. The conventional method of getting circular polarization is by the use of nearly square patch or square patch with diagonal slot. Those methods give 6 dB axial ratio bandwidth not more than 1 %. There are many methods reported in the literature with single feed circularly polarized antennas using square patch. The first single feed CP antenna is reported by P.C Sharma and K.C Gupta [1] using square patch with truncated corners and square patch with inclined slot. But the reported 6 dB axial ratio bandwidth is only 0.831 % and 1.134 % respectively with those antennas. M L Wong et al [2] presented a different method to get circular polarization mainly aiming for compact size by incorporating slots and adding tails to the square patch. But with that method the impedance and 3 dB axial ratio bandwidths are 1.61 % and 0.381 % respectively. J.S Row and C.Y.Ai [3] have proposed a compact design of single feed circular polarized antenna by cutting a crossed slot on the circular patch backed by square shaped ground plane with crossed slot, but the peak gain is very low which is in the order of 1.8 dBi and 3 dB axial ratio bandwidth is around 0.9 %. M.Elsdon et al [4] have reported a single feed star loaded patch antenna for circular polarization with 3 dB axial ratio bandwidth at 2.4 GHz around 1.1 % and the input impedance of the patch around 245 ohms to 705 ohms. Wen-Shyang Chen et al [5] have proposed a novel compact circularly polarized square Microstrip antenna. The gain with that antenna is only 1.4 dBi to 3.5 dBi. Kin- Lu Wong and Jian – Yi Wu [6] have proposed a single feed circularly polarized microstrip antenna by providing two pairs of narrow slits in the x and y directions of the square patch. The methods mentioned above may not give 0 dB axial ratio at the center frequency.

It seems there is a need to design a circularly polarized antenna which provides 0 dB axial ratio at the center frequency and should give at least 1% 3dB axial ratio bandwidth. Further the antenna should be perfectly matched to the line. In the present paper a novel technique is used to get circular polarization by the use of fractal curve as boundary which not only gives very good circular polarization but also compact in size.

II. ANTENNA GEOMETRY AND RESULTS

The proposed fractal boundary antenna can be obtained by replacing the boundary of square patch with the Koch fractal strip of width 1mm. The generation of the fractal curve is shown in fig. 1

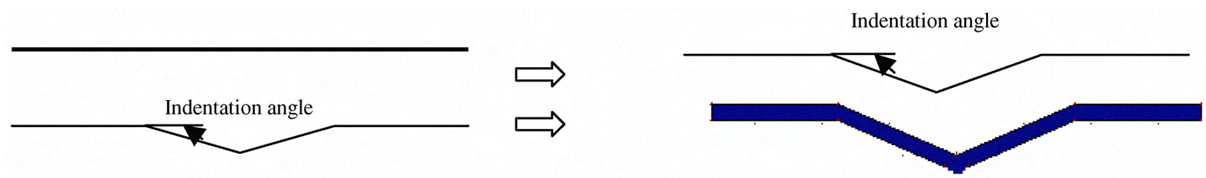

Fig 1: The generation of fractal curve

When all the Euclidean boundaries of the square patch are replaced by Koch fractal curve as shown in fig 1 with different indentation angles the proposed antennas with different indentation angles can be obtained. By doing so the electrical length is increased so that the resonance frequency will be decreased [7]. The electrical length can be changed by changing the indentation angle of the boundary [8].

Two cases have been considered in this paper, first one is linearly polarized fractal boundary antenna and the second one is circularly polarized antenna. The size of the patch is 36.4 X 36.4 mm^2 and is printed on RT Duroid substrate of thickness 3.2 mm with relative permittivity of 2.33. The antennas are analyzed using Zeland IE3D electromagnetic simulator. For linearly polarized case the antennas are fed along the y axis and keeping electrical length constant in both sides. In this case the behavior of the antenna for different indentation angles of the curve is studied. It is observed that as the indentation angle increases the resonant frequency is being shifted left towards the origin. Eight cases have been considered with different indentation angles. The geometries of the antenna for first four cases are shown in fig 2. The resonant frequency of the antenna is changed from 2195 MHz to 2056 MHz when the indentation angle is changed from 10^o to 45^oas shown in fig 3. The resonant frequencies for the different cases are given in table 1. All the antennas are 36.4 mm X 36.4 mm size.

A square patch antenna with same size operates at a frequency of about 2550 MHz. By slightly changing the indentation angle of the boundary the resonant frequency can be altered. This is very useful in designing circularly polarized antenna. For the circularly polarized case the antenna is fed along the diagonal but there will be slight difference in electrical lengths in two directions of the patch. This is achieved by the changing the indentation angle.

The proposed antenna gives axial ratio at the center frequency very close to 0 db, the 3 db axial ratio bandwidth of about 1% and 10 db impedance bandwidth of 3.25%. Further the size of the antenna is also reduced by more than 35% without much degradation in gain of the antenna. The antenna is fed along the diagonal at a distance of 8 mm from the origin where the antenna impedance is about 50 ohms. Right hand circularly polarized wave and left hand circularly polarized wave can be obtained by simply changing the feed point to the other diagonal. The variation of impedance, return loss and axial ratio with frequency are shown in figs 4-6.

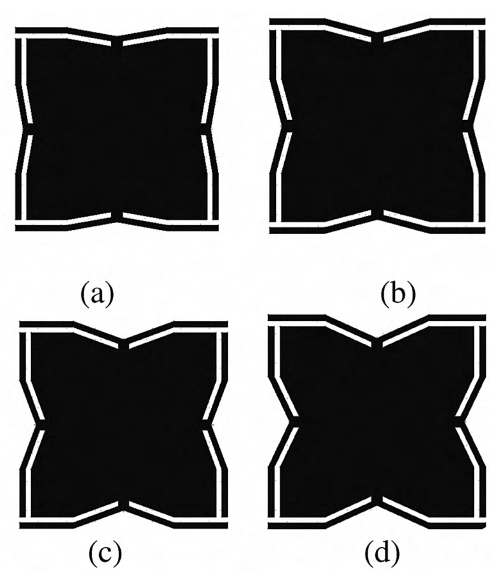

Fig 2: Geometry of the proposed antenna with Indentation angle (a) 10^o (b) 15^o (c) 20^o (d) 25^o

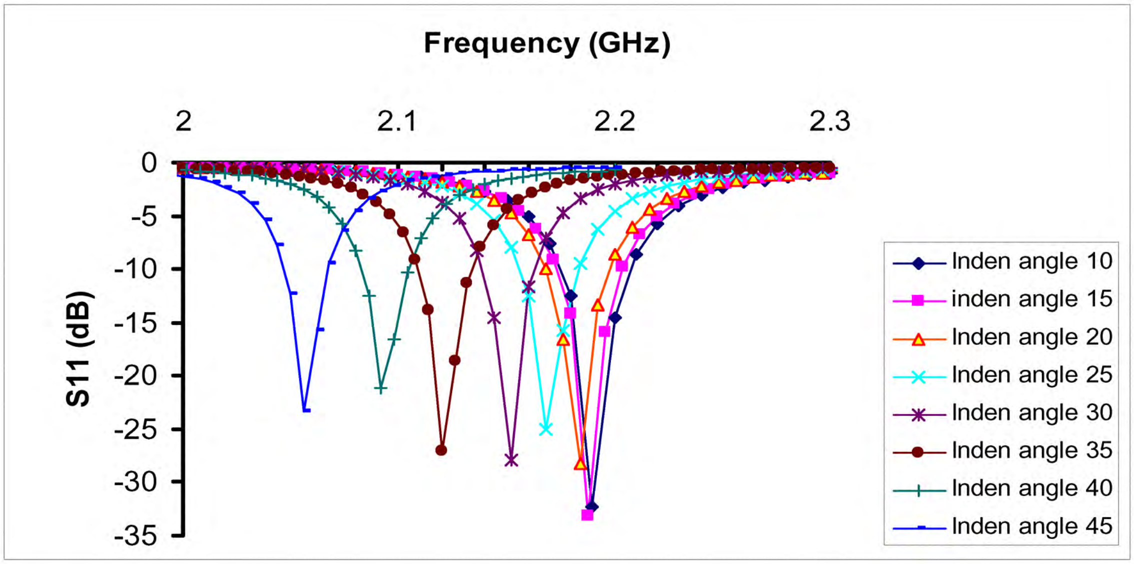

Fig 3: S11 Characteristic s of linearly polarized fractal boundary microstrip antenna

Table 1: Resonance frequencies of the proposed antenna for different cases

Antenna	Indentation angle	fo(MHz)
Antenna1	10	2195
Antenna 2	15	2188
Antenna 3	20	2184
Antenna 4	25	2168
Antenna 5	30	2152
Antenna 6	35	2120
Antenna 7	40	2092
Antenna 8	45	2056

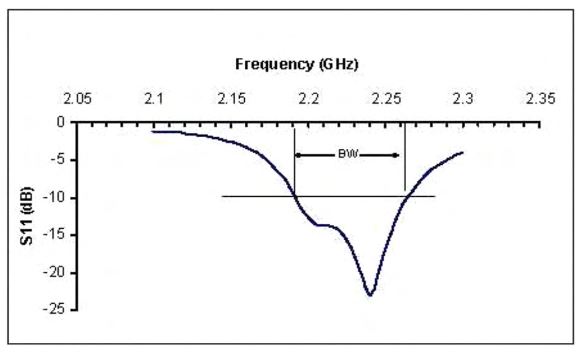

Fig 5: S11 characteristics of circularly polarized antenna

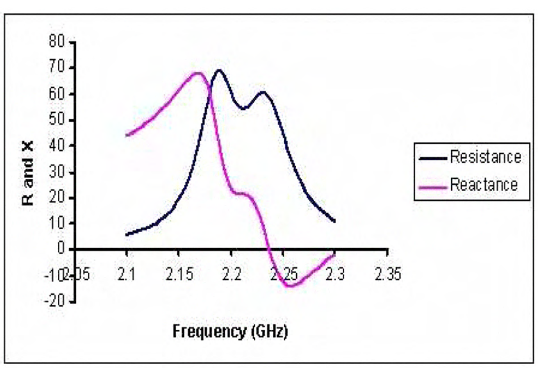

Fig 4: Input impedance of proposed CP antenna

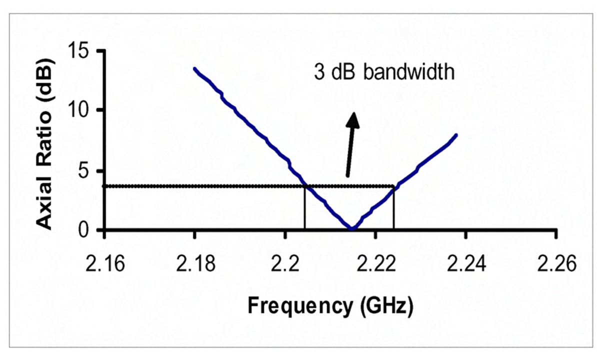

Fig 6: AR Vs frequency of the CP antenna

The Indentation angle of the boundary in x –direction is chosen as 20^o and in y-direction as 4.89^o to get circular polarization. The other indentation angles are also possible to get circular polarization. For the proposed antenna the range of frequencies over which the antenna providing axial ratio below 3 dB are within the band of frequencies over which the antenna is matched to the line as can be observed from the figs 5 and 6.

III. CONCLUSION

A compact circularly polarized fractal boundary microstrip antenna is presented. The antenna provides axial ratio very close to zero dB at the center frequency and operates over a band width of 1% (3dB AR bandwidth). It is established that by using a fractal curve as boundary it is simple and easy to design circularly polarized antennas.

REFERENCES

[1] P.C Sharma and K C Gupta, "Analysis and optimized design of single Feed Circularly Polarized Microstrip Antennas", IEEE Transactions on Antennas and Propagation., Vol-31, pp-949-955, Nov 1983.

[2] M.L Wong , H. Wong and K .M Luk " Small circularly polarized patch antenna ", Electronics Letters , Vol.41. No.16, pp-7-8, August 2005.

[3]. J.S Row and C Y Ai , " Compact design of single –feed circularly polarized microstrip antenna " , Electronic Letters, Vol. 40, No.18, pp-1093-1094, 2nd September 2004.

[4] M.Elsdon, A Sambell, S.C Gao and Y. Qin , "Compact circular polarized patch antenna with relaxed manufacturing tolerance and improved axial ratio bandwidth" , Electronics letters, Vol.39, No.18 , pp-1296- 1298, Sep-2003.

[5]. Wen-Shyyang Chen, Chun- Kun Wu and Kin –lu Wong , "Novel Compact circularly polarized Square microstrip antenna", IEEE Transactions on Antennas and propagation, Vol. 49, No.3, pp- 340-342, March 2001.

[6] Kin _Lu Wong and Jian Yi Wu , "Single feed circularly polarized square microstrip antenna" , Electronics letters , Vol. 33, No.22, pp 1833-1834, Oct 1997.

[7]. Carmen Borja , Jordi Romeu ," On the Behavior of Koch Island Fractal Boundary Microstrip Patch Antenna", IEEE Transactions on Antennas and Propagation , Vol - 51, No.6, pp.1281-1291, June 2003

[8] K. J. Vinoy, J.K Abraham and Vijay K.Vardan , " On the relationship between Fractal Dimension and the Performance of Multi- Resonant dipole Antennas Using Koch Curves", IEEE Transactions on Antennas and Propagations, Vol-51, No.9, pp. 2296-2303. September 2003.

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