Influence of the Feeding Position Over the Polarization Parameters of Patch Antennas with Different Geometric Shape

Milko V. Stefanov[1]

Abstract – **Circularly polarized microstrip patch antennas with three different shapes are designed. The influence of the feeding position by a coaxial probe over the polarization parameters – Axial Ratio and Crosspolarization is investigated. Depending on these parameters working area over the patch is defined.**

Keywords – circular polarization, crosspolarization, Axial Ratio, Cross-Polarization Discrimination

I. Introduction

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers, GPS receivers etc. Some of their principal advantages are: light weight and low volume, low profile planar configuration, low fabrication cost, hence can be manufactured in large quantities, supports both, linear as well as circular polarization, can be easily integrated with microwave integrated circuits, capable of dual and triple frequency operations, mechanically robust when mounted on rigid surfaces. Microstrip patch antennas suffer from a number of disadvantages as compared to conventional antennas: narrow bandwidth, low efficiency, low Gain, extraneous radiation from feeds and junctions, low power handling capacity, surface wave excitation [1].

A circularly polarized wave has two orthogonal field components that are in phase quadrature. Microstrip antennas can be designed to radiate circular polarization with one feed. It is possible to excite the two modes with one feed by introducing a small perturbation in the patch shape [2]. Many types of perturbations are used. One common configuration is a square patch with a small difference in length of the two opposite sides (asymmetry). This asymmetry can be also realized by adding two rectangular segments in the center of two opposite sides of the square patch. Therefore the orthogonal surface current path lengths are changed, of each additional segment. Therefore the resonant frequencies of the orthogonal modes are different. This difference depends on the segment size, which is designed to achieve phase shift of 90 degrees between the radiated fields.

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The next structure is designed by cutting of four rectangular segments near each corner of a square patch. Two opposite rectangles have little different length with the length of the other two rectangles [3]. In such a way the requirements of circularly polarization radiation are fulfilled. In the field of the circular polarized microstrip antennas two bandwidths are defined: impedance bandwidth and axial ratio bandwidth. The Axial Ratio Bandwidth is defined between the two frequencies where Axial Ratio equals 3 dB. In this bandwidth Minimal Axial Ratio is defined. The other important polarization parameter is the Crosspolarization Level. It may be measured with Cross-Polarization Discrimination (XPD) - the difference between the level of Radiation Pattern for working polarization and the opposite one.

All the polarization parameters depend on the shape of the patch, feeding system and the feeding position

II. Design of the Antennas

Dimensions design of patch antennas includes calculation of the resonant length, for central working frequency $f = 2.4GHz$. There are not simple analytical expressions for synthesis and analysis of the circularly polarized microstrip antennas because of the complex character of the field in the antenna. That's why numerical methods for analysis as Moments Method, Finite Difference Method etc. have to be used. In the current analysis models of microstrip antennas with different shape in the medium of a software package, working with Moments Method has been designed.

The antennas consist of dielectric substrate with $\varepsilon_r = 2.2$ and thickness h=0.7 mm. They are fed by a coaxial probe.

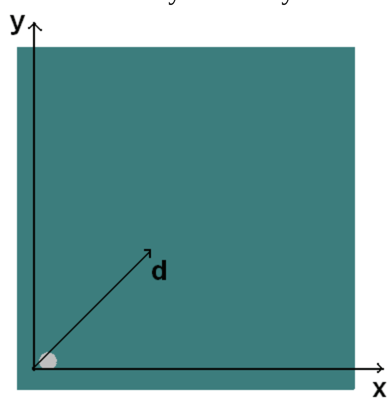

Fig.1. Nearly square microstrip patch antenna (geometry A).

III. Results from the Analysis

In the current article the relations between Axial Ratio (AR) and crosspolarization, measured with the difference between maximal levels of Radiation Pattern for working polarization and the opposite one (XPD), versus feeding position of the coaxial probe are investigated. Three structures of microstrip resonator on the dielectric substrate are designed – nearly square patch [1] - geometry A (Fig. 1), square patch with two rectangular segments in the center of two opposite sides - geometry B (Fig. 2), square patch with four cut rectangular segments near each corner [3], where the two opposite rectangles have little different length with the length of the other two rectangles geometry C (Fig. 3). The coaxial probe is moved along three directions – bisector of a corner (d-direction), horizontally (x-direction), vertically (y-direction). The initial point is x=y=2 mm.

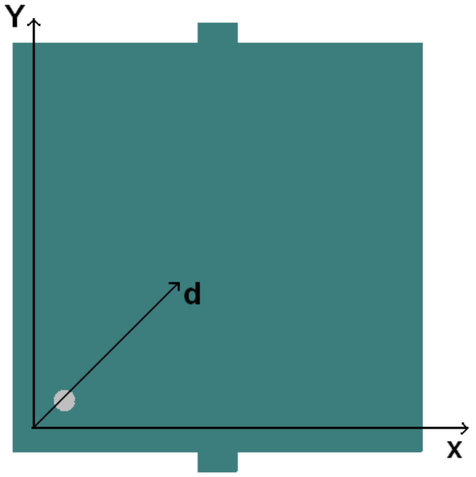

Fig.2. Square microstrip patch antenna with additional rectangular segments (geometry B).

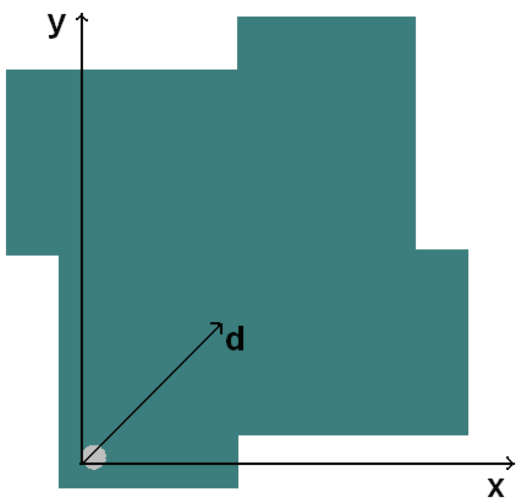

Fig.3. Square microstrip patch antenna with four cut rectangular segments near each corner (geometry C).

First important parameter is the minimal Axial Ratio (AR).

Fig. 4 shoes min AR versus probe position along x, y, d for nearly square patch witch is common used in the practice. min AR is almost constant along bisector, but strongly increasing along horizontal and vertical directions when x, y > 6. That separates an area around the diagonal of the patch.

Fig. 5 shoes the same relation for geometry B. min AR is constant along d, also along y, but for y < 7.5. Along y min AR strongly increases. Here working area between d and y directions is defined.

For geometry C (Fig. 6) the lowest level of min AR is between d and x-directions.

Geometry B has the lowest value of AR and it weakly depends on the feeding point.

The other important parameter is the crosspolarization measured with the Polarization Pattern level difference between working polarization (Right Hand Circular Polarization) and crosspolarization (Left Hand Circular Polarization). This difference is denoted by XPD (Cross-Polarization Discrimination). XPD should be grater than 20 dB.

Fig. 7 shoes XPD versus the probe position for geometry A. XPD is almost constant along x, y and d for x, y < 6 mm. After that XPD increases along d, but decreases under 20 dB along x and y, which degrades the antenna operation. This result along with the area with minimal AR determines the working area that is along d for x and y grater than 6 mm.

For geometry B the greatest values of XPD are between y and d directions when y < 7.5 mm (Fig. 8). This area coincides with that of minimal AR.

For geometry C maximal XPD is again between d and x.

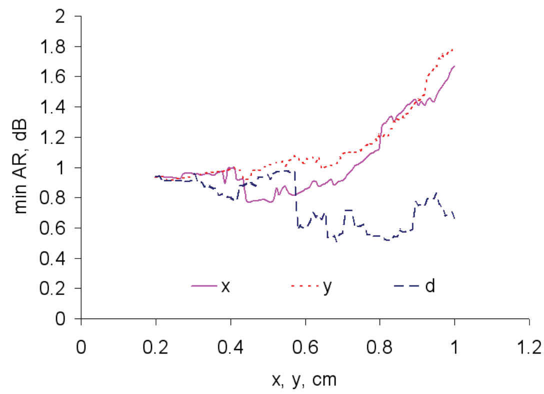

Fig.4. Min. AR versus x, y, d for geometry A

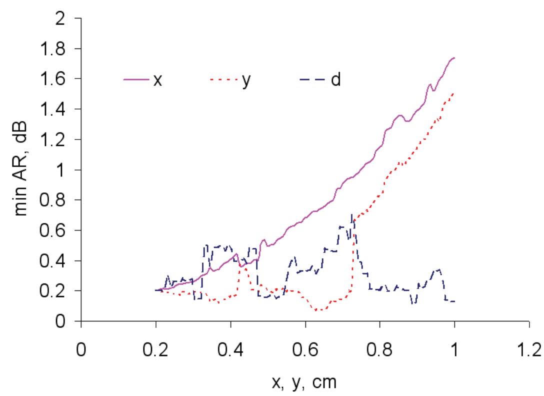

Fig.5. Min. AR versus x, y, d for geometry B

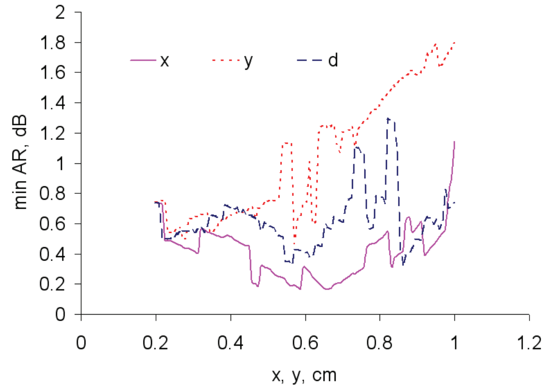

Fig.6. Min. AR versus x, y, d for geometry C

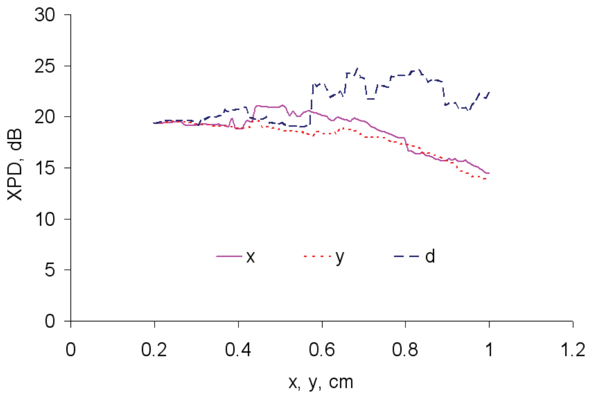

Fig.7. XPD versus x, y, d for geometry A

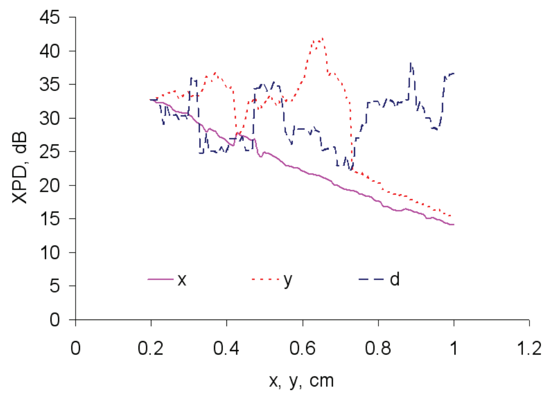

Fig.8. XPD versus x, y, d for geometry B

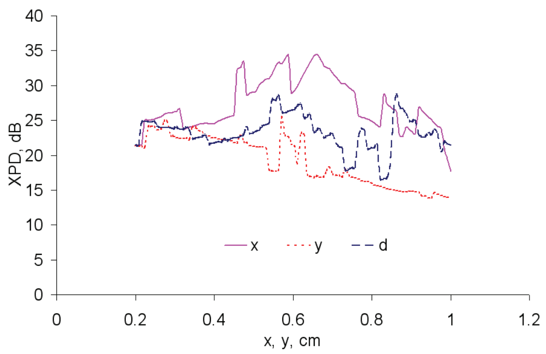

Fig.9. XPD versus x, y, d for geometry C

IV. CONCLUSION

From the results above some concussions may be drawn. When designing of circularly polarized microstrip antennas the choice of proper feeding position is important from the point of view of impedance matching, crosspolarization and minimal Axial Ratio. A wider working area with minimal crosspolarization leads to better impedance matching because an optimal feeding point with minimal VSWR, AR and maximal XPD may be chosen. Working area is strongly individual for one geometry and may be determined mainly by experiments and simulations. The geometry also determines the Axial Ratio Bandwidth. That's why patches with various shapes are designed.

REFERENCES

[1]. C. A. Balanis, *Antenna Theory: Analysis and Design*, second edition, John Wiley & Sons, New York, 1997.

[2]. R. A. Sainati, *CAD of Microstrip Antennas for Wireless Applications*, Artech House Inc., 1996.

[3]. H. M. Chen, K. L. Wong, "On circular polarization design of annular-ring microstrip antennas," *IEEE Trans. Antennas Propagat.* vol. 47, pp. 1289–1292, Aug. 1999