A square microstrip antenna with polarization switching by commutation elements

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Abstract – **Reconfigurable square microstrip patch antenna with adjusting its polarization sense is designed. Four rectangular slits with switching elements are made to adjust the polarization by switching one of the two pair elements. Axial Ratio versus frequency and radiation patterns are examined. It's suggested a method of decreasing of the crosspolarization.**

I. INTRODUCTION

Microstrip patch antennas are widely used in wireless applications due to their low-profile structure. They are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers, GPS receivers etc [1].

Antennas with switching of polarization sense are used for realization of polarization diversity. This is a method to double the channel capacity in one connection because RHCP (Right Hand Circular Polarization) and LHCP (Left Hand Circular Polarization) are orthogonal. The simplest method to switch the polarization is to construct two separate feeding systems for the two polarization senses, but they have to be independent and not to influence each other. The design and fabrication are complicated. Because of that methods with including additional elements on the patch are used. In [1], a four-element polarization-agile microstrip array is presented, where each square patch is loaded with four varactor diodes, one on each edge; microstrip arrays with a phase-shift circuit; using of in-plane biased ferrite substrates are presented in [2]. In this article the switching properties of PIN diodes are used. These properties are determined by the direction of the forward biased dc current with very low level [3]. In switch applications the PIN diode should ideally control the RF signal level without introducing distortion which might change the shape of the RF signal.

Polarization switching can be realized by microstrip patches with different shape. It has to be kept the condition to radiate circularly polarized wave – generation of two orthogonal field components that are in phase quadrature

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 two rectangular slits in the two opposite sides of the square patch. Therefore the orthogonal surface current path lengths are changed, respectively the resonant frequencies of the two modes have a small difference and a circularly polarized wave is radiated. If such slits are made in the other two sides, full symmetry is achieved and the antenna is linearly polarized. To restore the asymmetry a PIN diode in switching mode is placed to the end of each slit. When two opposite PIN diodes are forward biased, the other diodes are reverse biased. The surface current paths to the end of two adjoining sides of the patch are different. Therefore the resonant frequencies of the orthogonal modes are different. This difference depends on the slit size, which is designed to achieve phase shift of 90 degrees between the radiated fields.

When the other couple of PIN diodes are forward biased, circularly polarized wave with the same parameters is radiated, but with the opposite sense of polarization.

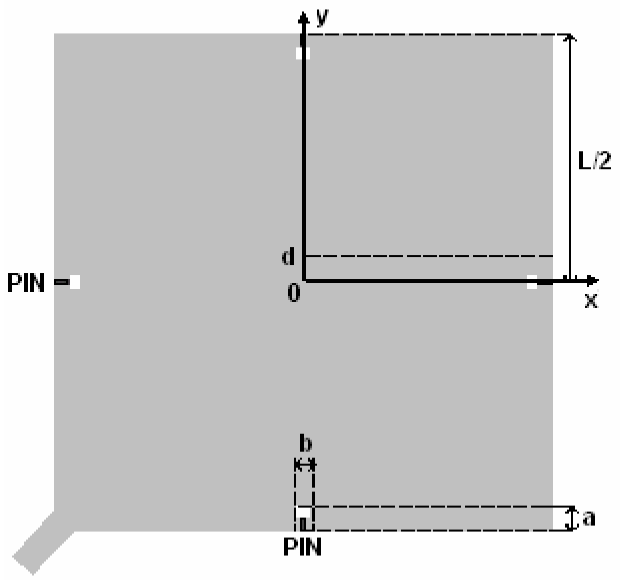

Fig. 1. Circularly polarized microstrip antenna with switching of the polarization sense

II. DESIGN OF SQUARE PATCH WITH POLARIZATION SWITHCING

Dimensions design of a square patch antenna includes calculation of the resonant length, for central working frequency $f = 5GHz$. There are not simple analytical expressions for synthesis and analysis of the circularly polarized microstrip antenna 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 a model of a square microstrip antenna with side slits by the medium of a software package, working with Moments Method has been designed. Iteratively the nominal patch size L is determined.

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The antenna consists of dielectric substrate with $\varepsilon_r = 2.2$ and thickness h=0.5 mm. It is fed by a microstrip line included diagonally to one of the corners of the patch.

Slits dimensions (a and b) are also determined iteratively by contiguous changing of the length and width of each one until the necessary radiation characteristics are achieved.

Polarization switching is easy modeled by the substitution metal bridges for the forward biased PIN diodes, but slits for the reverse biased diodes.

The slits can be made in the center of each side as well as shifted each one to a distance d. That is a method for decreasing the crosspolarization radiation and minimal level of Axial Ratio (AR).

III. RESULTS FROM THE ANALYSIS

On the basis of models of square microstrip antenna with side slits and commutation elements the variations of the axial ratio with the frequency (fig. 2 and 4) and radiation patterns for the necessary polarization and crosspolarization (fig. 3 and 5) are obtained.

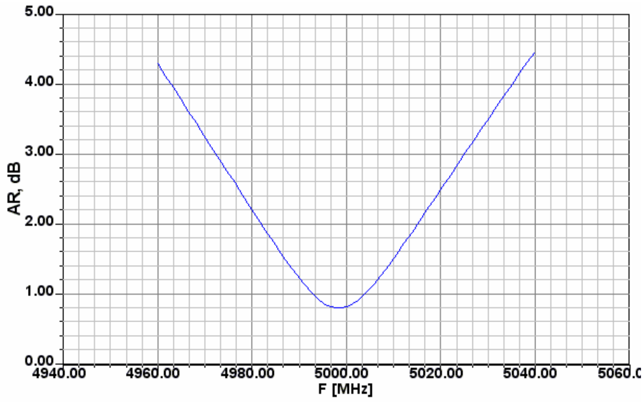

Fig. 2. Axial Ratio versus frequency, d=0, RHCP and LHCP

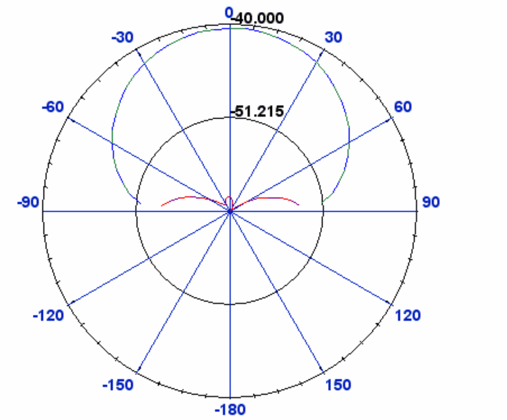

Fig. 3. Radiation pattern, d=0

TABLE I

NUMERICAL RESULTS

L, mm	a, mm	b, mm	d, mm	ARBW, MHz	min AR, dB
19.57	0.4	1	0	52	0.8
19.57	0.4	1	0.2	53	0.2

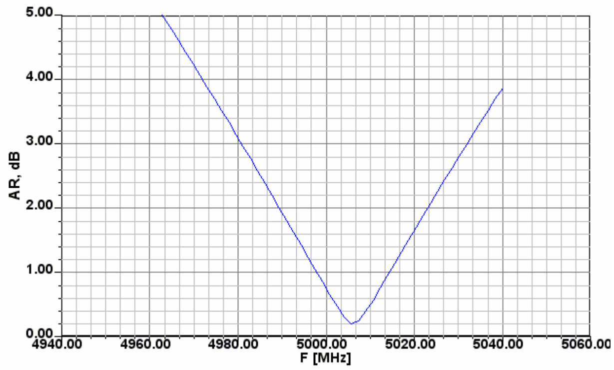

Fig. 4. Axial Ratio versus frequency, d=0.2 mm, RHCP and LHCP

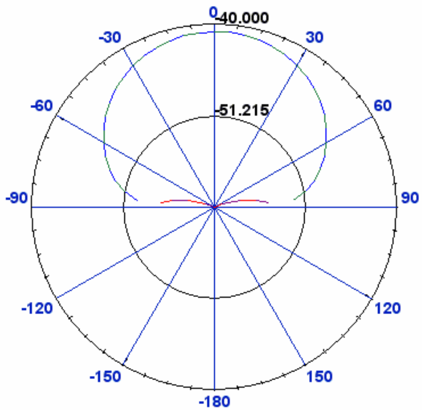

Fig. 5. Radiation pattern, d=.0.2

In the first case the slits are made in the center if each side of the patch (d=0). From Fig. 2 Axial Ratio Bandwidth (ARBW=52 MHz) can be determined. Minimal Axial Ratio is AR=0.8 dB. Fig. 3 shoes that the difference between the polarization and crosspolarization level is 20 dB

In the second case the slits are shifted toward the center to a distance d=0.2 mm. Therefore minimal AR decreases to 0.2 dB, ARBW is little increased, but the crosspolarization difference is increased to 22 dB.

IV. CONCLUSION

In this paper a circularly polarized antenna with polarization switching has been analyzed from the view point of the polarization characteristic – Axial Ratio and respectively Axial Ratio Bandwidth. By the switching of the respective couple of PIN diodes RHCP or LHCP wave is radiated.

Minimal AR and crosspolarization level are decreased by shifting of the slits to a small distance.

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