Polarization improvement in pin-fed patch antenna associated with lateral displacement of feed point

Yordan Kechev[1], Peter Petkov[2] and Mario Gachev[3]

Abstract – **This paper presents a new technique for polarization improvement of pin-fed patch antennas. In order to obtain higher bandwidth and dual polarization, stacked patch with two orthogonal pin excitations is used. To achieve lower cost and compatibility with standard PCB manufacturing process RO4003 substrates are used. Simulations are made with full wave 3D FEM simulator HFSS.**

Keywords – **Polarization improvement, Dual polarized microstrip antenna, Pin fed patch antenna, Stacked patch antenna, Planar antenna array.**

I. Introduction

Dual polarized patch antennas are widely used in communications and radar systems. Their easy implementation using standard PCB manufacturing process and their low profile make them suitable for many applications. One of the most common issues in dual polarized patch antennas are cross polarization level and isolation between two ports. The insufficient isolation between ports cause degradation of antenna performance and deteriorate signal to noise ratio (SNR) of a system. Cross polarization level depends on mutual coupling between two ports and, in case of antenna array, on mutual coupling between radiating elements. The problem was investigated in case of aperture coupled dual port patches in [1,2] and good isolation between ports and high cross polarization ratio was reported. Another papers [3,4] present balanced pin-fed patch antennas. Low cross polarization levels are reported due to the proper balanced feeding. In this paper a new technique for cross polarization ratio reduction is proposed.

II. Antenna Geometry and Design Technique

Fig. 1 represents geometry of pin-fed dual polarized patch antenna for Ku band. To achieve wider bandwidth stacked patch antenna configuration is used. Simplifying the measurement process, a proper pin to microstrip transitions are designed and entire antenna with transitions is simulated using HFSS full wave 3D simulator. Antenna comprises the following main parts:

- Feed substrate – RO4003 0.020” (0.508 mm);
- Bottom patch substrate – RO4003 0.020’’ (0.508 mm);
- Parasitic patch substrate – RO4003 0.032’’ (0.813 mm);
- Feed microstrip lines width – 1.14 mm;
- Orthogonal pins diameter – 0.6 mm;
- Bottom patch diameter – 3.45 mm;
- Parasitic patch diameter – 3.2 mm;

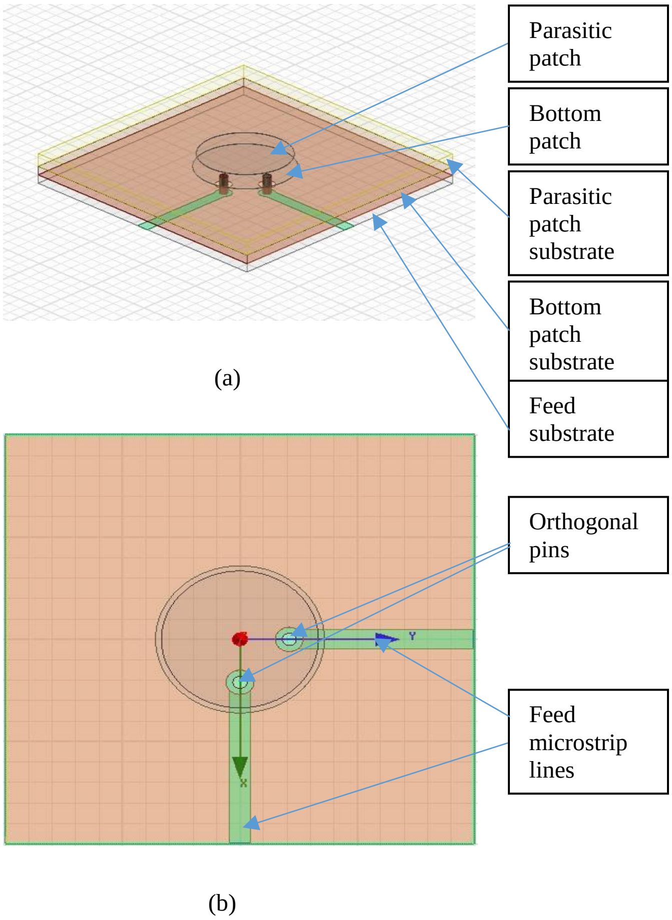

Fig. 1 Structure of dual-polarized patch antenna. (a) Three-dimensional view. (b) Top view.

To obtain two orthogonal polarizations, two orthogonal wave modes need to be excited. This is achieved using two orthogonal pins to feed the antenna. In the commonly used design feeding pins are oriented along the X Y axis (as it is shown on Fig 1 (b) and the polarization ratio of the antenna depends mainly on the mutual coupling (isolation) between two ports. The radiation patterns for co and cross polarization are

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shown on Fig.3 (a) and Fig.4 (a). As it can be easily seen the cros polarization ratio is approximately close to between ports isolation. The proposed antenna configuration in shown on Fig.2. Using the proper feed points displacement a significant cross polarization suppression could be achieved.

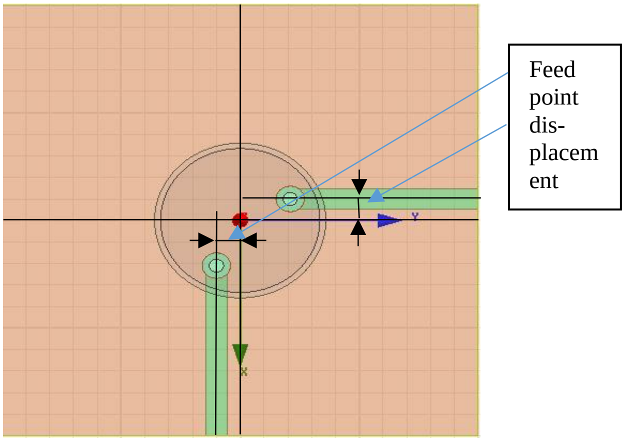
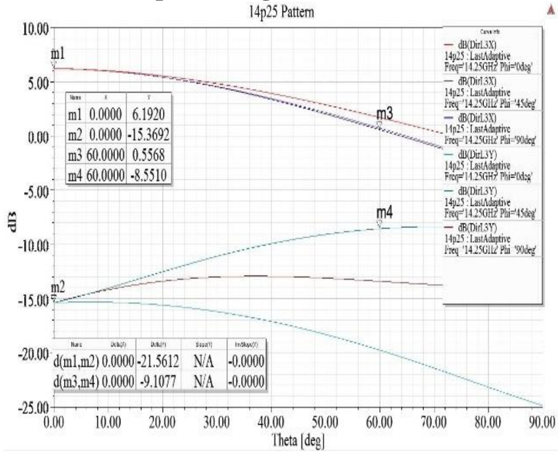


Fig. 2 Top view of patch antenna with lateral displacement.

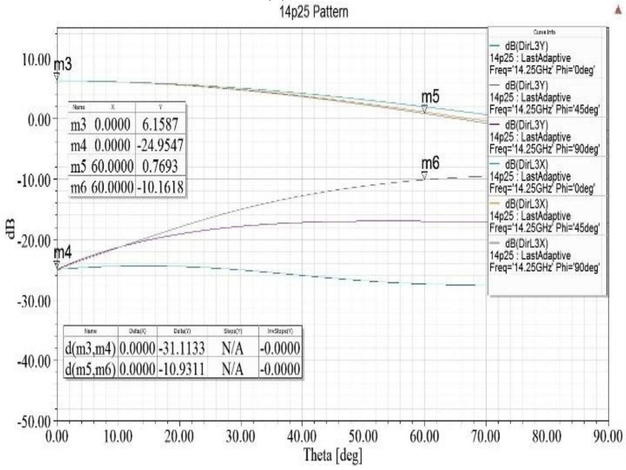
As it is shown both pins have displacement from their nominal position. Pin for “vertical” polarization (X axis) has offset negative to other (Y) axis and pin for “horizontal” polarization (Y axis) has offset negative to X axis or in other words when one of ports is displaced (negative to Y axis) other port is image of first along the same axis (Y) and then second port is rotated on 90 degrees. With this offset degradation of polarization ratio and isolation between ports is expected because of rotation of field vector from nominal coordinate system (0xy on Fig.2) and non-orthogonality between ports. As it is shown on Fig.4 isolation between ports decrease, so mutual coupling is increased and cross-polarization components are transferred. Cause of image copy and rotation of second ports from the first one, these cross – polarization components have 180 degrees phase difference and their sum is zero. Due to this phase difference polarization ratio of antenna is increased without degrading of radiation pattern symmetry and characteristics for the main polarization as it is shown on (Fig.3).

III. Simulation Results

Fig.3 shows radiation pattern for co- and cross – polarizations for nominal design and for the proposed technique. Patches have dimensions close to λ/2 and antenna resonate at its main mode H_{11}. Patterns are symmetrical in different azimuthal cuts and have maximum directivity at boresight about 6 dBi. Fig.3b shows 10 dB increasing of polarization ratio on boresight at 14.25 GHz compared to standard design (Fig.3a). At the same time no significant degradation in return loss between two designs is observed as it can be seen from (Fig.4). Isolation between ports is decreased from 20 dB(Fig.4a) to 17.5 dB(Fig.4b) but the cross-polarization ratio is significantly improved due to the feeding points displacement as it was explained above.

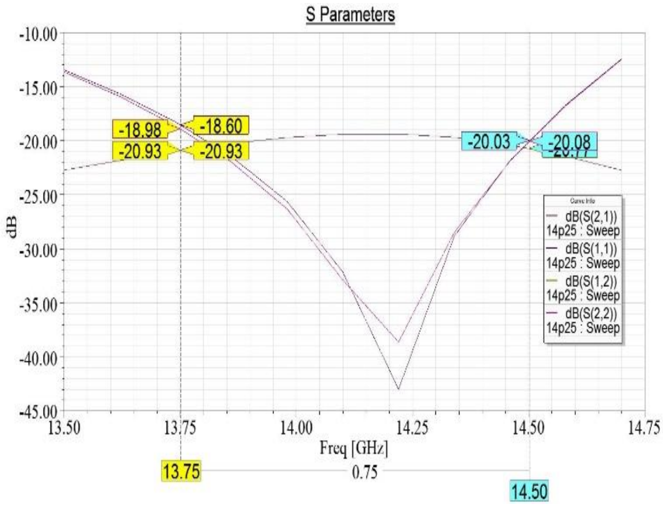


(a)

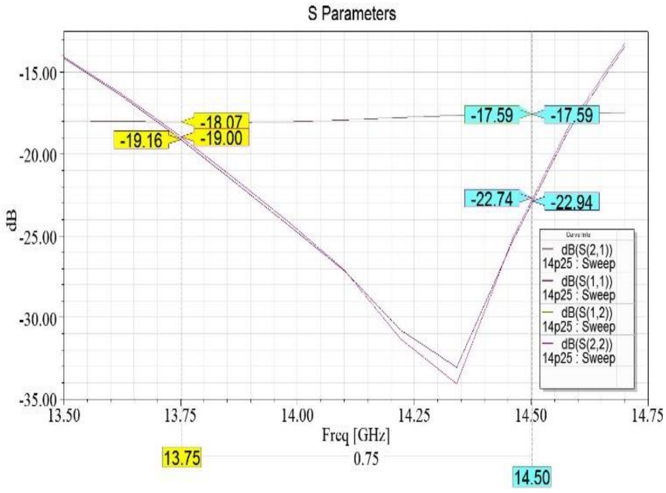


(b)

Fig.3 Radiation pattern for both polarizations. (a) Without lateral displacement. (b) With lateral displacement.

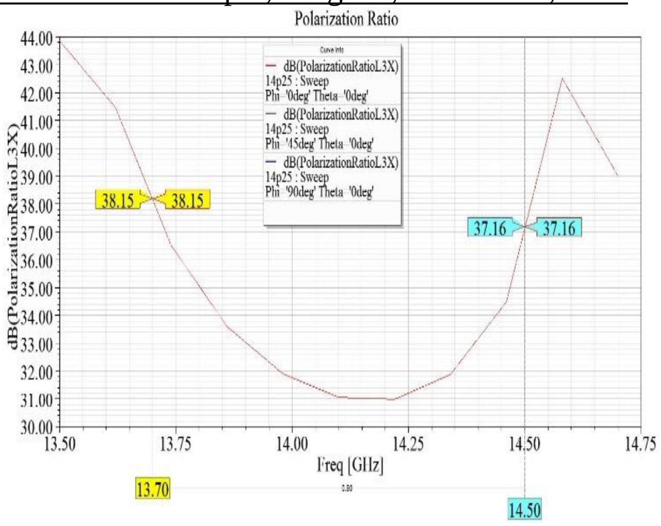


(a)



(b)

Fig.4 Scattering Parameters of the antenna. (a) Without lateral displacement. (b) With lateral displacement.



(b)

Fig.5 Polarization ratio of nominal design and proposed technique. (a) Without displacement. (b) With displacement.

The cross polarization ratio improvement using the proposed techique can be clearly seen from the graphs shown on Fig.5, Fig.6 and Fig.7. They represents two cases:

- (a) standard design;
- (b) design using the proposed technique;

Used offsets are optimized to be 200 um for both ports in order to achieve symmetry. The results from simulations show 10-15 dB higher cross-polarization suppersion in the proposed design compared with the standard one. Improved cross-polarization performance could contribute significantly for better antenna performance, reducing interferience and iproving of the communication link signal-to-noise ratio .

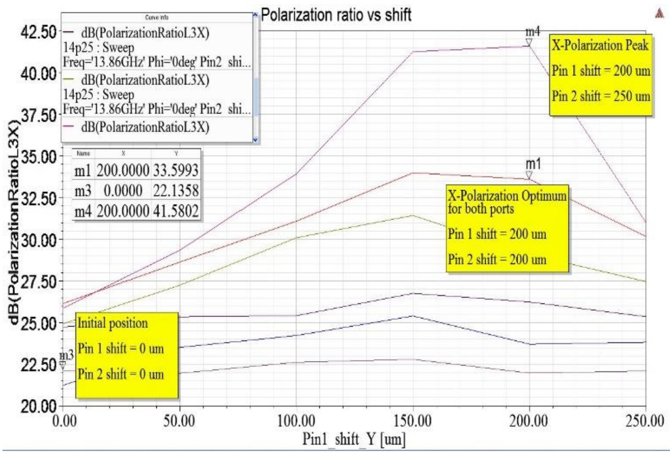
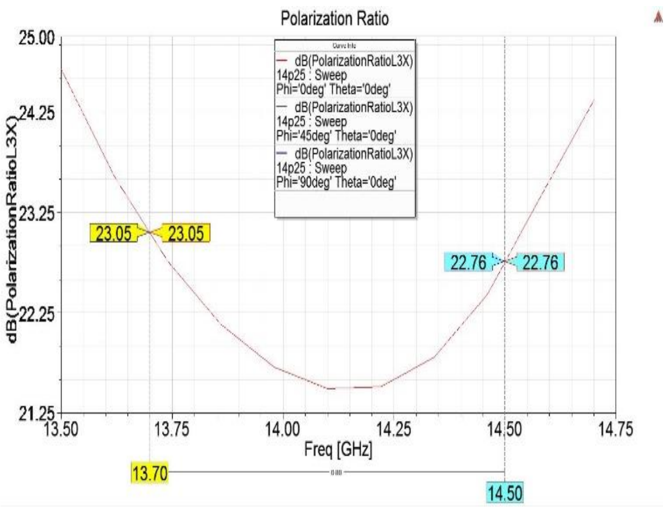
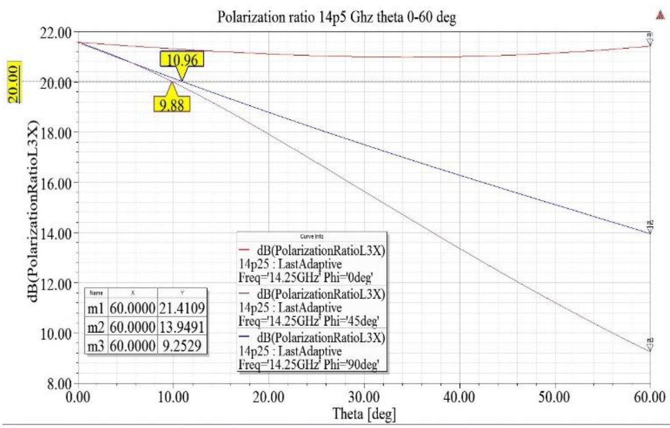


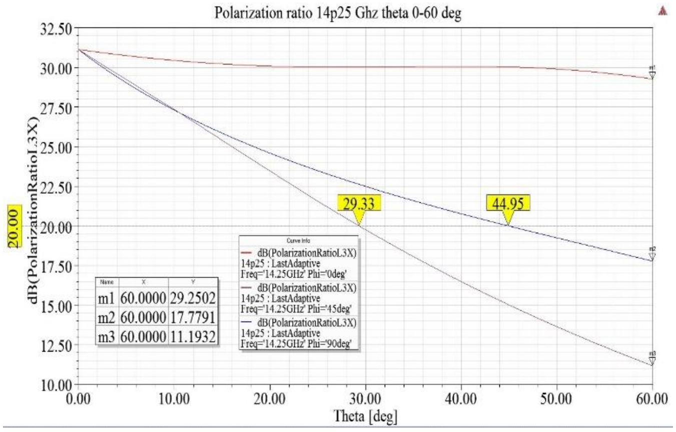
Fig.6 Polarization ratio with different ports shift.



(a)



(a)



(b)

Fig.7 Polarization ratio for 0 to 60 degrees elevation (Theta) and in three azimuthal cuts (Phi). (a) nominal design. (b) With optimum offset.

IV. Conclusion

A new technique for polarization ratio improvement of two port patch antenna is presented. It allows to improve significantly cross polarization ratio using proper displacement of antenna feeding points. Simulation shows 10-15 dB improvement of cross polarization isolation at boresight compared to the between port isolation. Some improvement can also be achieved in case of using such antenna in scanning arrays for different antenna beam tilts. From another side no changes in S- parameters and Directivity of the antenna were observed. The prosed design of dual port patch antenna can be successfully implemented in antenna arrays for communication and radar applications.

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