Dual-Polarized and Compact Microstrip Patch Antenna

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Abstract - *A compact, Dual-fed microstrip patch antenna for operation in dual-polarization mode is proposed. This design is achieved by etching out a symmetric pattern of crosspatch slots from the surface of a square patch. Patch Size is also reduced up to 50% with respect to a traditional dual-polarized square patch operating at the same frequency. The Antenna radiates at 3.1Ghz and 4.2Ghz which is more optimal for wireless communications. The feed along the diagonals makes easy for fabrication*

Index Terms—Compact microstrip antenna, dual polarization

1.INTRODUCTION

The explosive growth in broadband wireless communication systems, with rapid advances in the variety and sophistication of the data-intensive wireless services being offered, has increased the demands to enhance information accessibility and created a need for more bandwidth-efficient communication techniques. One way to address the capacity increase is by employing polarization diversity [1], [2]. Recent results in communication theory [3] have demonstrated that deploying dual-polarized antennas at the transmitter and/or receiver can dramatically increase both the capacity and diversity of wireless communication links. For example, in the richly scattering environments considered in [3], a dual-polarized antenna at the transmitter can increase capacity by more than 50% over a single transmit antenna; employing dual-polarized transmit and receive antennas can increase capacity threefold over a comparable system with single antennas at the transmitter and receiver. This paper focuses on the development of a novel microstrip antenna characterized by polarization diversity. The objective was to explore strategic antenna designs for dual-polarization coverage and determine the feasibility of seamlessly integrating such antenna systems on mobile nodes in a wireless system. Due to their intended application on mobile network nodes such as portable laptop platforms, compactness was a key issue that was considered in the designs. Dual polarization can be accomplished by exciting modes in two orthogonal directions [4]–[7], while size reduction can be achieved by means of reactive loading in the form of notches or slots on the surface of the patch [8]–[10]. Such loading causes the meandering of the surface current, thus effectively increasing the surface current path and the electrical length of the element that leads to reduction of the patch size for a given resonant frequency. Simultaneous etching out of a symmetrical array of slots and the excitation of two orthogonal modes can lead to an antenna with reduced size operating in dual-polarization mode. In this paper, we propose a dual-feed probe-fed antenna design with a symmetrical array of slots etched on the patch surface. Results show that the proposed antenna is characterized by excellent isolation between the two ports (38 dB) and is more than 50% smaller compared to a traditional dual-polarized square patch operating at the same frequency. Critical issues in the design are examined, and both simulated and experimental results are presented.

2. ANTENNA DESIGN

Fig. 1 shows the proposed probe-fed dual-polarized microstrip patch antenna. Four pairs of crossed slots are etched out—one from each quadrant of the surface and a smaller pair from the center of the patch. The square microstrip patch has a side length and is printed on a substrate of thickness and relative permittivity. For antennas in this paper, laminates with a relative permittivity were utilized. The quadrant slot pairs have their sides parallel to the edges of the patch and have length and width. The slot pair in the center has length and width. Due to the specific locations of the feed points, the polarizations at the two ports will be along the orthogonal diagonals of the square patch. The finite-difference time-domain (FDTD) algorithm is employed to design and analyze the antenna. For least cross polarization, it is critical that the slots be etched out in a symmetrical pattern such that the surface currents in both the orthogonal directions have to traverse identical paths. To achieve good isolation between the two ports, each feed point is positioned along the “null-line” of the other port, which comprises all of the locations on the patch where the normal electric field to the patch obtained by feeding the other port is minimum. DH FDTD method with material independent perfectly matched layer (PML) boundary condition [11], [12] was used during the design phase of the antenna to locate the position of the null line and, therefore, the location of the feed points. A resolution of 0.762 mm has been used to model the antenna, leading to a total computational space of 160* 160*60 cells. Fifteen PML layers have been used to absorb the outgoing waves with PML parameters chosen as specified in [11] and [12]. The FDTD method was also used to obtain the directivity in dBi of the final antenna designs. Confidence in the accuracy of the result was based on an extensive comparison of radiation patterns and directivity obtained for conventional antenna geometries as well as results reported in the literature. Excellent agreement between the numerical results and data reported in the literature was found for all the considered test cases.

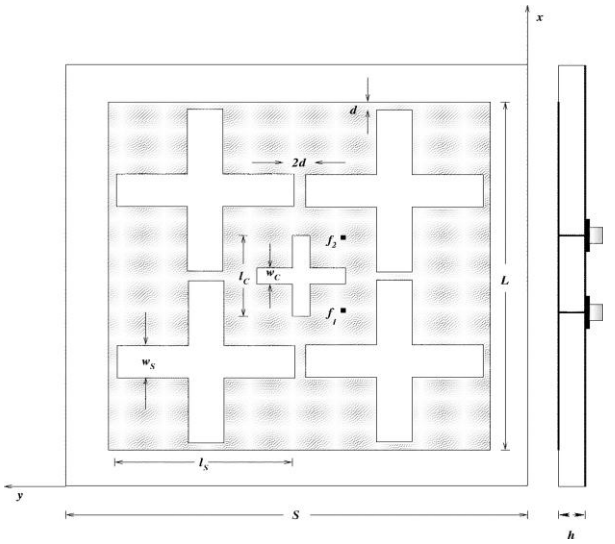

Fig.1 Design parameters for proposed Antenna

Antenna dimensions

We have also shown the practical design in Fig.2

The fabricated antenna is also shown in Fig 2a and in the center we can see the two feeding structures $\mathbf{f_s}$ and $\mathbf{f_i}$ respectively. Since it has feeding along the diagonals of the square patch it is easy to fabricate. We take the length of the substrate **L**=67.056 mm, width of the substrate is 1mm. We have four similar cross patches whose length $\mathbf{l_s}$=30.480 mm and $\mathbf{w_s}$=3.048mm. There is one small cross patch whose length $\mathbf{l_c}$ and $\mathbf{w_c}$ are 18.288mm and 3.048 mm respectively.

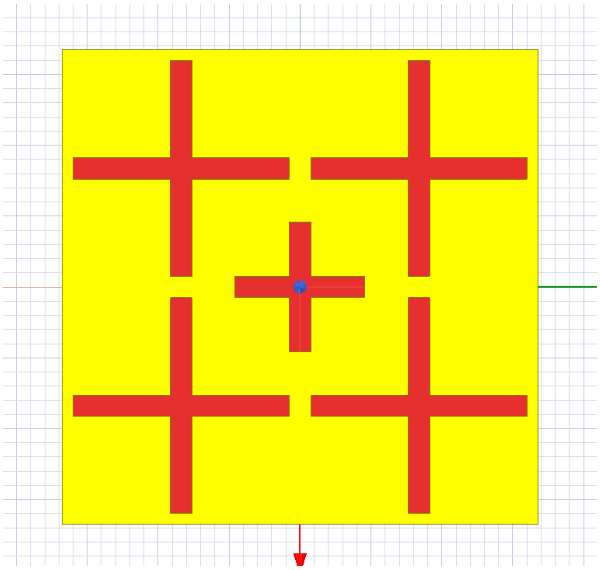
Fig. 2 The practical design of proposed Antenna

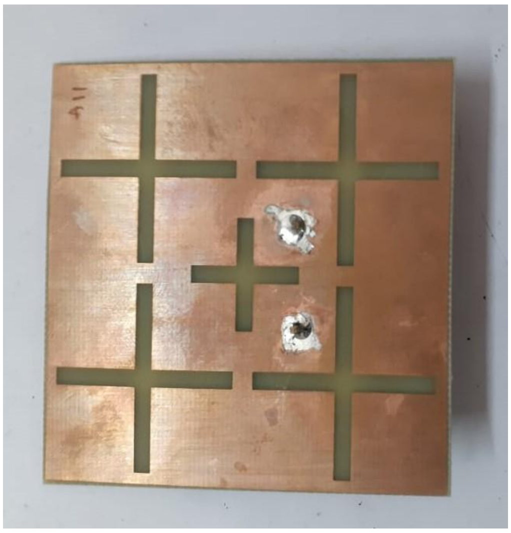
Fig. 2a Fabricated Antenna of proposed Antenna

2.1 IMPEDANCE AND ISOLATIONCHARACTERISTICS

It can be observed that the antenna exhibits excellent impedance matching to 50. Also, isolation greater than 36 dB throughout the operating impedance bandwidth (1:2 VSWR) is observed in Fig 2.1. The slight discrepancy between numerical and measured return losses (including a 20-MHz resonant frequency shift, which is, however, less than 2.5% shift with respect to the resonant frequency) can be attributed to both fabrication tolerances and FDTD tolerances in the precise modeling of slots and edges as well as the absence of losses in the computer model.

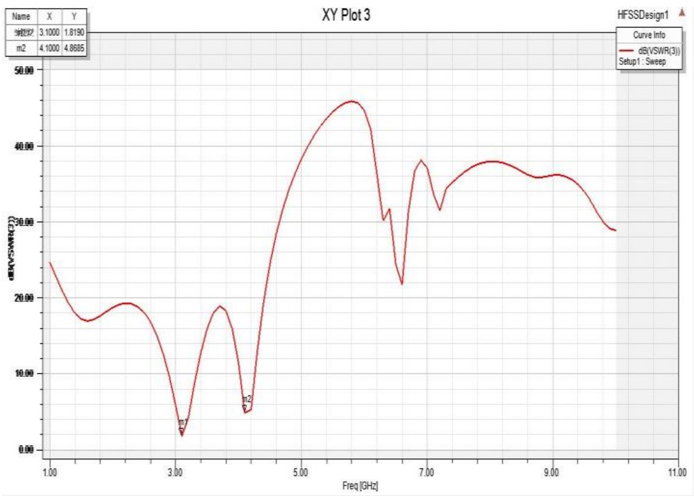

Fig 2.1 VSWR Plot

3. RESULTS AND DISCUSSIONS

The effect of the slot lengths and widths on the size reduction factor, impedance, and radiation characteristics of the antennas has been investigated. Specifically, first we consider the effect of reducing the corner slot lengths and then the effect of reducing the corner slot widths with respect to that of Antenna, which is used as the benchmark antenna and found to be the antenna with the largest size reduction ratio. For comparison purposes, a reference antenna (a conventional unslotted patch) operating at the same frequency as Antenna was also implemented and its characteristics measured. An HP 8510 network analyzer was utilized for all the measurements.

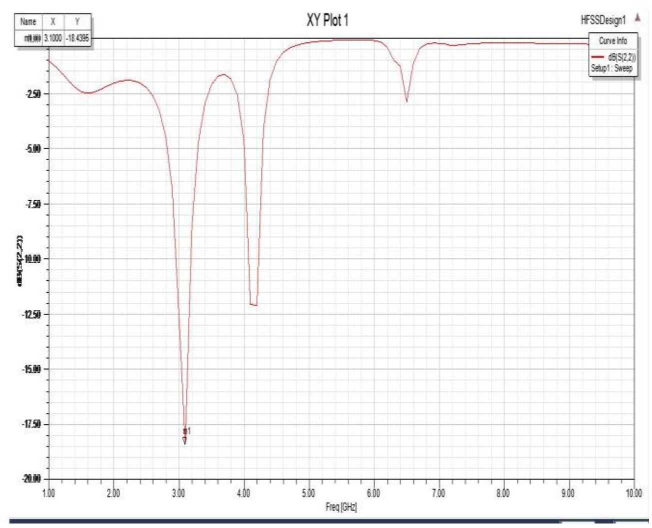

Fig 3.1 Return loss

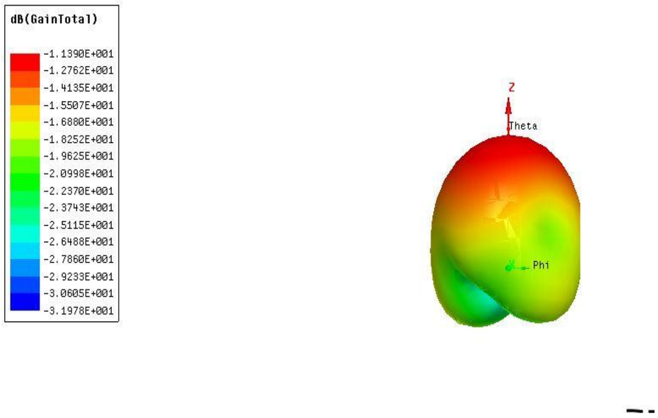

Fig 3.2 Total Gain Plot

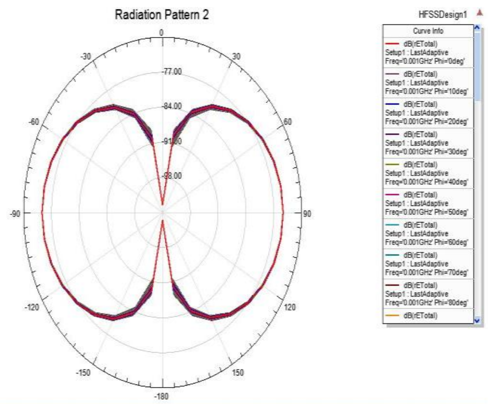

Fig 3.3 2D Radiation Pattern

4. CONCLUSIONS

A novel, compact, dual polarized microstrip patch antenna is presented. In the proposed design a size reduction of 50% with a high isolation(38dB)and low Cross-polarization level is demonstrated, albeit, with a reduction in the broadside directivity (by 3.9 dBi). The influence of the slot parameters was investigated, and a tradeoff between slot dimensions, directivity and size reduction factor is shown. Due to their compactness the proposed antennas are suitable for application on mobile wireless nodes operating in dual polarization mode.

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