Low Cross-Polarization Differential Feed Patch Antenna Array

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Abstract - *A low cross-polarization dual-polarized patch antenna is designed for phased array radar applications. Differential feeding technique is used to reduce the cross-polarization level of the designed patch antenna. A 2×2 element array of the designed unit cell is designed and fabricated. The antenna is excited using an external phase shifter and a 1 to 4 power divider. The antenna s-parameter results are measured and compared with the simulation results. The antenna radiation pattern is measured in the far-field anechoic chamber. The measured results show a cross-polarization level lower than -30 dB.*

Key Word: Dual-Polarized, Patch Antenna, Balanced-Feed Antenna, Array Antenna, Phased Array.

1.INTRODUCTION

With the recent development of Printed Circuit Board (PCB) fabrication technology which allows low cost and precise fabrication of planar antennas, microstrip patch antennas have become a great candidate for design and fabrication of large phased array antennas. Replacing traditional reflector antennas with phased array antennas have undergone several studies in recent years. In the theory of phased array antennas, the antenna radiation pattern direction can be steered to any direction, simply by introducing the excitation phase shift between phased array antenna elements which is called electronic beam steering. Comparing to the traditional reflector antennas, the phased array radar, depending on the design, does not necessarily require any mechanical rotation, which results in higher beam agility and faster data update for phased array antennas. Also, eliminating the mechanical rotation of radar antenna, will increase the system stability and reduce the maintenance costs [1]- [2].

In dual polarized phased array antennas, it is required to achieve low cross-polarization levels. Various configurations are recently proposed to achieve this goal [4]- [8]. The proposed design, in this paper, has a very low cross-polarization level and provides high isolation between two polarizations.

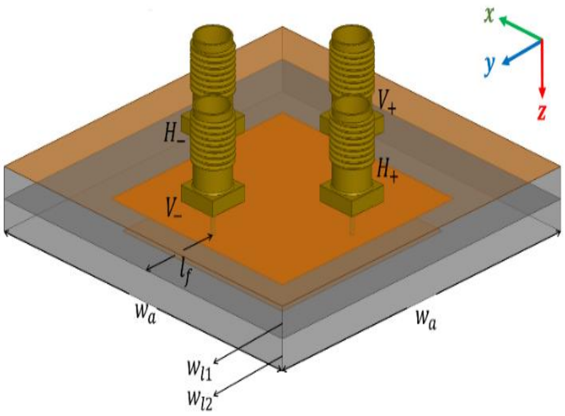


Fig -1: The proposed dual-polarized balanced feed patch antenna.

2. Single Element Design

The geometry of designed single element is shown in Fig. 1. Among different possible choices for a single element, the balanced-feed microstrip patch antenna has the advantage of the low cross-polarization radiation pattern, high-isolation between horizontal and vertical ports and symmetric co- and cross-polarization radiation patterns. In the balanced feed patch antenna, there are two horizontal and two vertical excitation ports for each element. The two horizontal or vertical ports are excited with the 180° phase difference. Having two excitation ports with 180° phase difference will suppress the propagation of higher order modes and will result in a low cross-polarization and symmetric radiation pattern [9]-[12]. Although the balanced feed microstrip patch antenna has many advantages over another type of single elements, realizing an ideal a balanced feed patch antenna with integrated feed lines even in a wide bandwidth is so difficult. In integrated design, the coupling between horizontal and vertical ports will degrade the performance of the elements. The coupling between horizontal and vertical feed lines can be improved by increasing distance between them, however, this will result in higher element width which can cause grating lobe and scan blindness. In this design, the feed lines are separated from a single element and the excitation ports of the designed element are excited by an external power divider. Design parameters of the presented patch antenna are provided in Table I. The substrate material is Rogers 5880 with the thickness of 3.175mm. The dielectric constant of 5880 is 2.2. Using low-dielectric material will result in a higher impedance bandwidth. As seen in Figure 1, the antenna is excited using four 50-ohm SMA connectors. To increase the bandwidth of the designed patch antenna, a parasitic rectangular patch is placed over the excited patch

Table -1: Design Parameters.

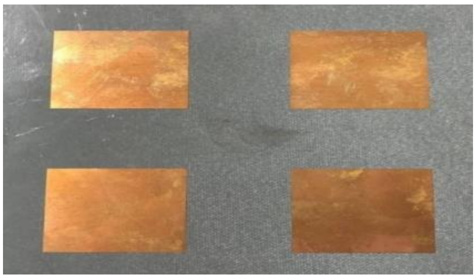
parameter	Value
w_a	50 mm
w_{l1}	3.175 mm
w_{l2}	3.175 mm
w_{lf}	13 mm
w_r	33 mm
w_p	32 mm

2. Array Design

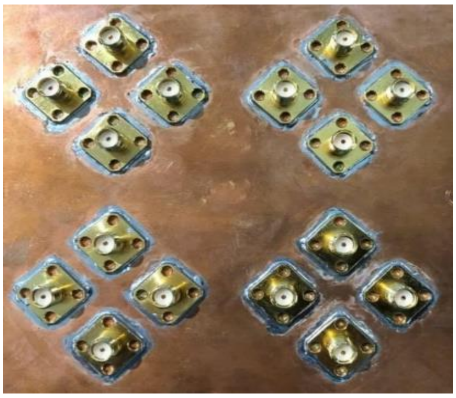
The 2×2 element array of presented differential feed patch antenna is designed and fabricated. As mentioned in Table I. the spacing between array elements is 50 mm. The designed array antenna is precisely fabricated and simulation and measurement results are provided in this section.

The photograph of the fabricated array antenna is presented in Fig. 2. The return loss of the antenna is measured using Agilent Technologies network analyzer and measurement results are provided in Fig. 3. As seen in Fig. 3, both simulated and measured return loss result of horizontal and vertical polarizations are below -14 dB in the entire frequency band. It is worth noting that since each polarization is excited through two 180° out of phase ports, the input coupling resulted from each port of one polarization on the orthogonal polarization will be 180° out of phase compared to the other port. This means that although the presented horizontal to vertical polarization port coupling is close to -10 dB, the actual coupling will be very low since the coupling resulting from the other port will cancel this -10-dB coupling.

The measured radiation pattern of designed array antenna at the center frequency of operation bandwidth is shown in Fig. 4. The array radiation pattern is measured in the far-field anechoic chamber. Both Horizontal and vertical polarization radiation patterns are normalized to their copolarization peak power. As seen in Fig. 4, there is a great agreement between simulated and measured copolarization patterns. As shown in Fig. 4 (a-d), We managed to achieve the cross-polarization level of below -30 dB in the measurements. The summary of maximum measured return loss and cross-polarization level are provided in Table II.



(a)



(b)

Fig -2: Photograph of the fabricated array antenna; (a) Top view, (b) Bottom view.

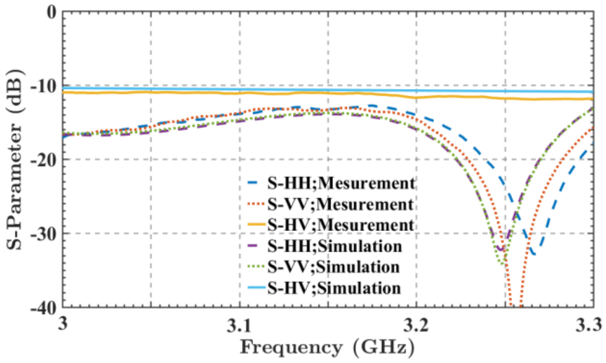
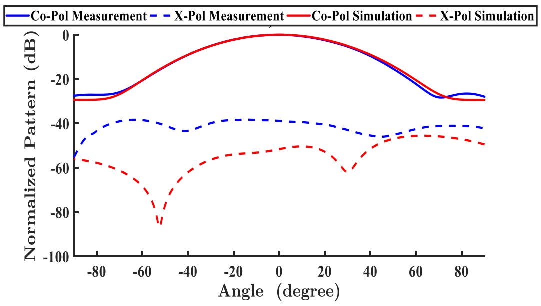
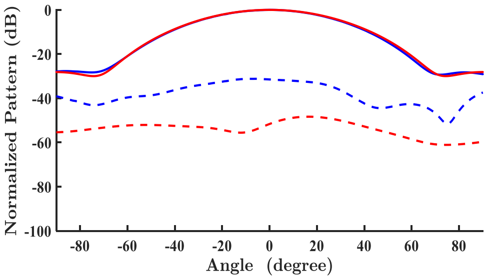


Fig -3: simulated and measured return loss and coupling between excitation ports.



(a)



(b)

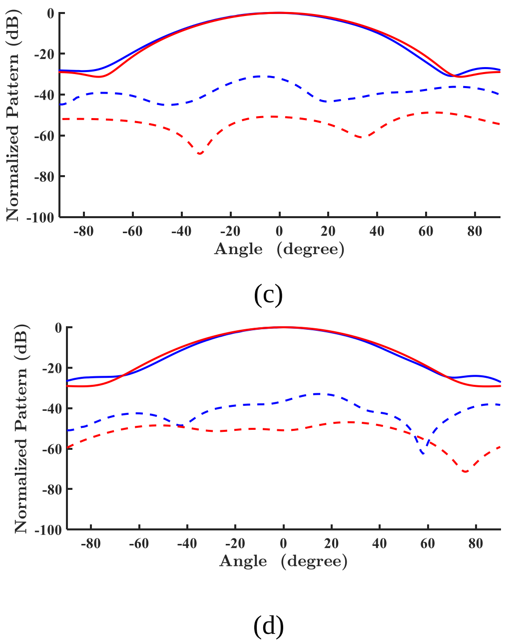


Fig -4: Simulated and measured horizontal polarization and vertical polarization radiation pattern of the 2x2-element array; (a) H-pol, φ=0° plane, (b) H-pol, φ=90° plane, (c) V-pol, φ=0° plane, (d) V-pol, φ=90° plane.

Table -2: Summary of measured results.

Cross-pol, H-pol, φ=0°	-37
Cross-pol, H-pol, φ=90°	-31 dB
Cross-pol, V-pol, φ=0°	-31 dB
Cross-pol, V-pol, φ=90°	-33 dB

3. CONCLUSIONS

A very low cross-polarization level patch antenna is proposed for phased applications. the two polarizations are excited using balanced feed technique. The designed array antenna is fabricated and -30 dB cross-polarization level has been achieved from measurement results.

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