

A Wideband Dual Linear/Circular Polarized 64-Element Phased Array Antenna for SATCOM Applications

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Abstract— In this paper, a flat panel 8x8 phased array with a radio frequency integrated circuit (RFIC) based beamforming network (BFN), is proposed. The array works in dual linear in addition to dual circular polarizations over a bandwidth of 22-28 GHz, with a realized gain of 22-23 dBi/dBic in the broadside direction. The array achieves better than 3dB scan loss to $\pm 50^\circ$ and offers axial ratio (AR) below 3dB over the entire bandwidth within the proposed scan range. The array is comprised of innovatively engineered radiating elements, arranged distinctively in a 2x2 sub-array level, thereby improving cross-polarized fields and axial ratio.

Keywords—Phased array, wideband, beamforming network (BFN), radio frequency integrated circuit (RFIC).

I. INTRODUCTION

Phased array antennas radiate ample power in an intended direction with rapid beam steering capability [1]. Recently phased array antennas with silicon radio frequency integrated circuit (RFIC) based beamforming networks have attracted significant attention [2]–[3]. In [4], the authors have presented a preliminary study on an 8×8 dual linear/circular polarized passive phased array antenna where a conventional stacked patch approach is chosen as a wideband radiating element. In this work, an engineered stacked patch with improved bandwidth and cross-polarized fields is employed as a radiating element. Moreover, the radiating elements are arranged in an innovative way such that the advantage of mirror effects [5] is achieved to improve cross-polarized fields in dual linear polarizations, and the advantage of sequential rotation of elements [6] is achieved to improve axial ratio (AR) for dual circular polarizations. This antenna is designed to meet the requirements of a dual band (22.55-23.55 GHz and 25.5-27.5 GHz) Tx/Rx array for a National Aeronautics and Space Administration (NASA) mission concept of an orbiting lunar relay that can provide constant connectivity to the lunar south-pole. An elaborate discussion of the novel 8x8 phased array is presented in [7].

II. 8X8 PHASED ARRAY AND SIMULATED RESULTS

Fig.1 shows the top view of the 8x8 antenna aperture integrated with the beamforming network and an exploded view of the 2x2 sub-array and single radiating element. The single radiating element consists of a stacked patch with L-shaped stubs at the two opposite corners of the driven patch and tuning stubs on radiating edges of both the driven and parasitic patches,

which helps to achieve improved cross-polarized fields and axial ratio, along with widening the impedance bandwidth.

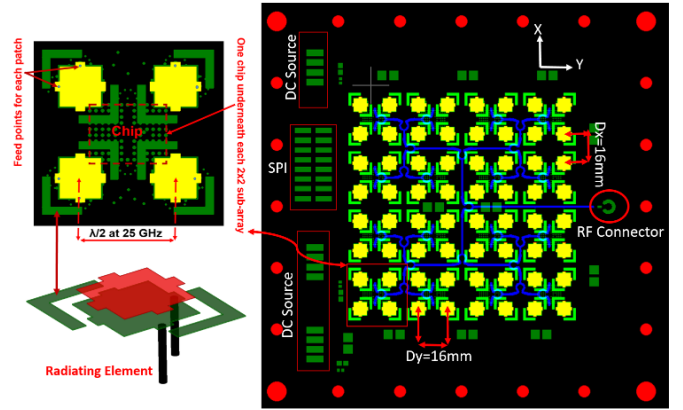


Fig. 1. Top view of the 8x8 antenna aperture integrated with the BFN with zoom in view of the 2x2 sub-array and single radiating element.

Adjacent elements in each 2x2 sub-array are mirrored along vertical and horizontal planes which reduces cross-polarized fields by a significant amount in dual linear operational cases [6]. For dual circular polarization cases, this same arrangement works as a sequentially rotated array [7], thereby improving AR by a significant amount. An Anokiwave chip is placed at the center of each 2x2 sub-array beneath the BFN, as indicated in Fig. 1. Each chip supports four dual-polarization radiating elements and provides programmable phase distribution for the mirror and sequential arrangements, in addition to polarization diversity.

The simulated scan performance of the 8x8 array at 25 GHz in the E-plane ($\phi=90^\circ$ plane) for the vertically polarized case is shown in Fig. 2(a). The gain drops from 23 dBi to 19 dBi as the beam scans from $\Theta = 0^\circ$ to $\pm 50^\circ$ along the $\phi=90^\circ$ plane. Fig. 2(b) shows the scan performance of the left hand circular polarized (LHCP) case in the $\phi=0^\circ$ plane. Here, the gain drops from 23.1 dBi to 19.8 dBi as the beam scans from $\Theta = 0^\circ$ to $\pm 50^\circ$. Fig. 2(c) shows the scan loss versus scan angle and AR versus scan angle for the $\phi=0^\circ$ plane at 23.05 GHz (center frequency of 22.55-23.55 GHz), 25 GHz and 26.5 GHz (center frequency of 25.5-27.5 GHz) for the LHCP case. We can see the axial ratio is well below 3dB to the 3dB scan loss point. The performance in $\phi=0^\circ$ plane is identical. The right hand circular polarization (RHCP) performance is exactly similar to LHCP performance also. The

vertically polarized and horizontally polarized cases show exactly the same results with E-plane and H-plane interchanged.

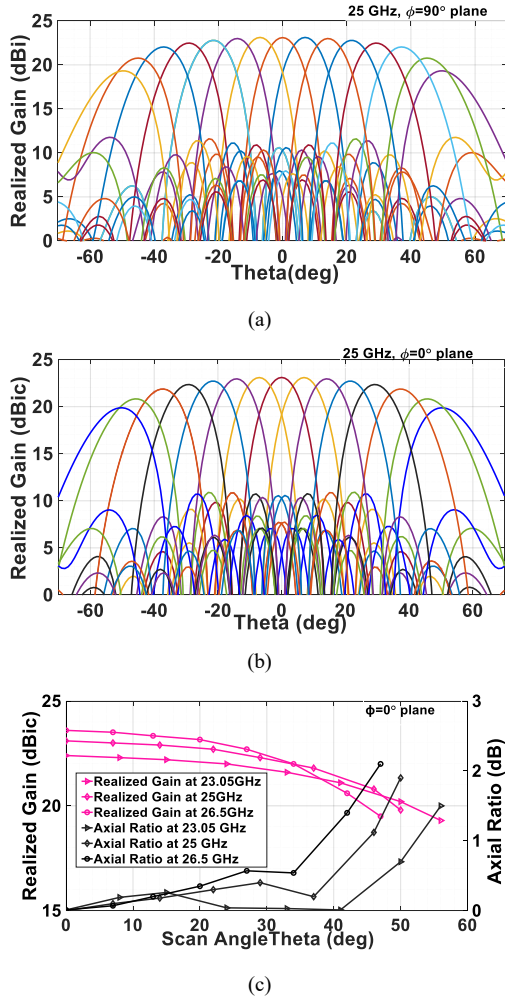


Fig. 2. (a) Beam scan for vertically polarized case in $\phi=0^\circ$ plane, (b) beam scan for LHCP case in $\phi=90^\circ$ plane at 25 GHz, and (c) scan loss and AR vs. scan angle in $\phi=0^\circ$ plane at 23.05 GHz, 25 GHz and 26.5 GHz.

III. FABRICATION AND MEASUREMENT RESULTS

The photograph of the fabricated prototype is shown in Fig. 3(a). Fig. 3(b) shows the measured magnitude plot for LHCP (co-polarization) and RHCP (cross-polarization) at the 30° scan position and 26.5 GHz. The measured axial ratio is found to be 1.4dB at a -30° scan position in the $\phi=0^\circ$ plane, which is in close agreement with simulation.

IV. CONCLUSION

A multipurpose 8x8 phased array antenna that covers 22-28 GHz bandwidth and works in dual linear and dual circular polarizations, is presented. The array is found to scan to $\pm 50^\circ$ within a 3dB scan loss and the axial ratio is below 3dB over the entire given scan range. The simulated results are discussed in brief and validated by measurement results. Additional simulation and measurement results will be presented during the conference.

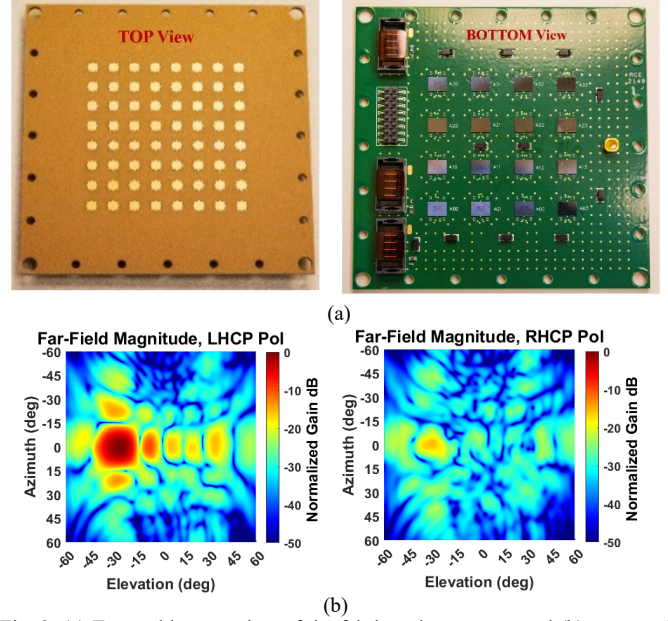


Fig. 3. (a) Top and bottom view of the fabricated prototype, and (b) measured LHCP and RHCP magnitude plots at 26.5 GHz for -30° scan position in $\phi=0^\circ$ plane.

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