Dual Circularly Polarized Waveguide Antenna Array for Satellite Communications in the X Band

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***Abstract* - In this paper, a novel dual circular polarization waveguide antenna array with wide band and low axial ratio is presented at X-band. Planar horn array is used to attain dual circular-polarization working with orthomode transducer and rectangular side wall coupler. A demo array of 16×16 elements is designed, manufactured and tested. The experimental results show that the AR is less than 1.5dB, the VSWR is less than 1.5 in the operation frequency band.**

***Index Terms* —dual circular-polarization；wide band; waveguide antenna；low axial ratio.**

I. INTRODUCTION

New fixed and mobile satellite systems require antenna systems that must be low-profile and light weight to provide ubiquitous and high-capacity communications-on-the-move. Planar antennas are perfect candidates for meeting these specifications [1]. Microstrip patches [2] are often used as radiating elements, but waveguide antennas [3-4] are preferable due to their ease of manufacturing and lower loss especially for X-band. Although phased arrays can reconfigure an antenna system to point in a desired direction, low cost systems are in high demand. Hybrid mechanical/electronic steerable solutions reduce costs but more expensive and difficult to design than a fixed beam array antenna. The main goal of this research is to design and measure a waveguide array antenna that could be used as an on-the-move with a high efficiency and cover a wide frequency band for satellite communication services.

The antenna was designed to be planar, compact, modular and dual circular polarized for transmission (Tx) and reception (Rx) bands simultaneously. It is composed of a square planar array of 16×16 horns fed by orthomode transducer and two planar waveguide feeding network to create two orthogonal modes in the horn and the dual circular polarization. The antenna covers a wide bandwidth (12%) for transmission and reception along with dual and interchangeable circular polarization. A radiation efficiency above 80% is achieved by a low low-loss waveguide feeding network. The measured axial ratio is under 1.5dB over the entire frequency band.

II. ANTENNA DESIGN

The antenna is formed by an array of 16×16 waveguide horns and is divided into 64 equal subarrays of 2×2elments. The distance between horns is 28.625mm and a total length of 458mm, is designed and fabricated for operation at X-band. Fig. 1 shows a schematic of the array composition and different layers of the antenna. The upper two layers correspond to the subarrays, while the middle three layers are the excitation network. The former has a waveguide technology feeding structure of orthomode transducer and 3dB rectangular side wall coupler for RHCP and LHCP. Fig.2 shows the photograph of the dual circularly polarized waveguide antenna.

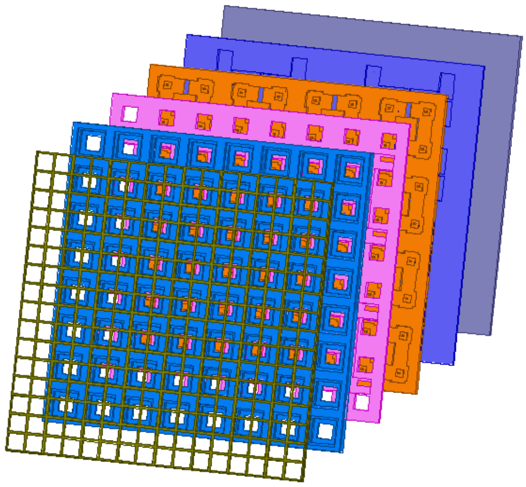


Fig. 1. Structure of the waveguide antenna.

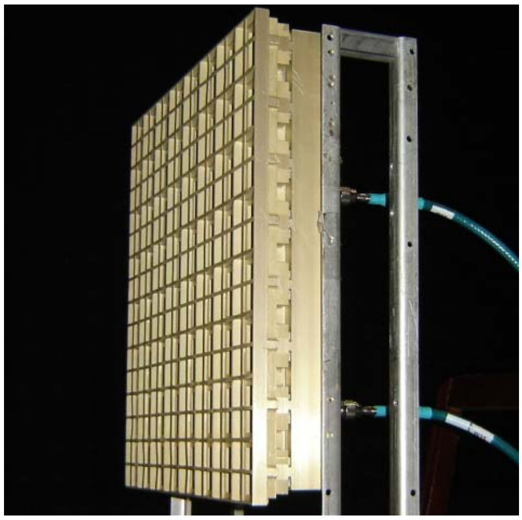


Fig. 2. Photograph of the waveguide antenna.

III. EXPERIMENTAL RESULTS

The complete antenna was measured successfully. Fig. 2 depicts the final antenna mounted in an anechoic chamber for measurement acquisition.

Fig. 3 shows the measured VSWR of the two waveguide ports. The VSWR of two ports remains under 1.5 over the entire band, which is sufficient to ensure a radiation efficiency above 80%.

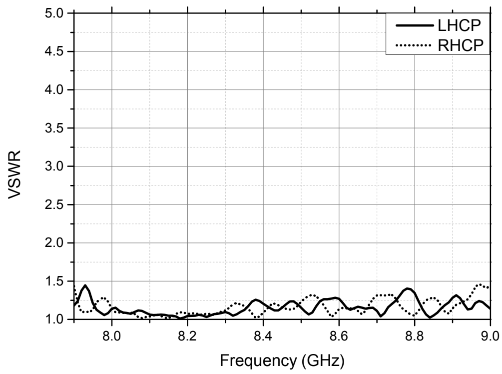
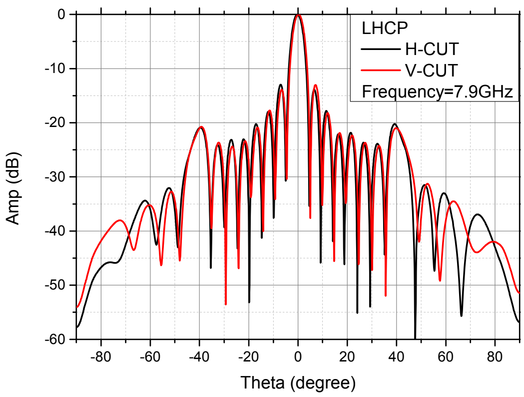


Fig. 3. Measured VSWR for the antenna

Fig. 4 shows the measured radiation patterns and axial ratio at 7.9GHz. The measured maximum sidelobe level is less than -13dB for both RHCP and LHCP. The measured axial ratio remains below 1.5dB for both polarizations.



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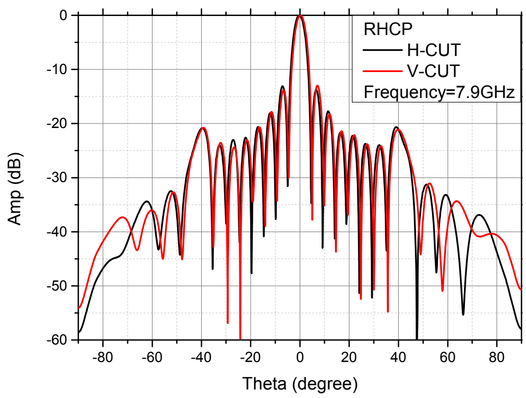

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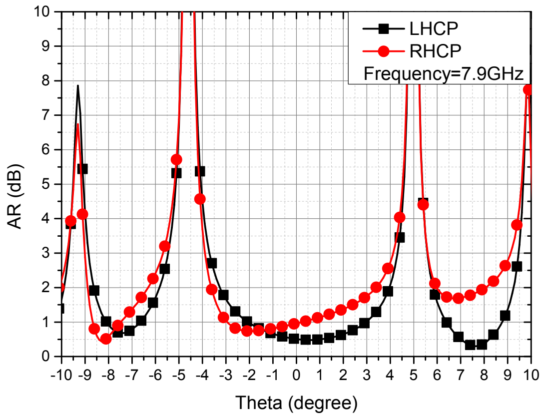
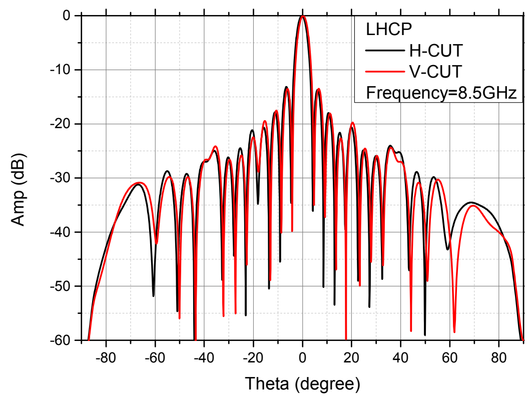


(c)

Fig. 4. Measured radiation pattern and axial ratio of the antenna at 7.9GHz for (a) LHCP and (b) RHCP, (c) axial ratio.

Fig. 5 shows the measured radiation patterns and axial ratio at 8.5GHz. The measured maximum sidelobe level is less than -13.15dB for both RHCP and LHCP. The measured axial ratio remains below 1.0dB for both polarizations.

Fig. 6 shows the measured radiation patterns and axial ratio at 9.0GHz. The measured maximum sidelobe level is less than -13.83dB for both RHCP and LHCP. The measured axial ratio remains below 1.3dB for both polarizations.



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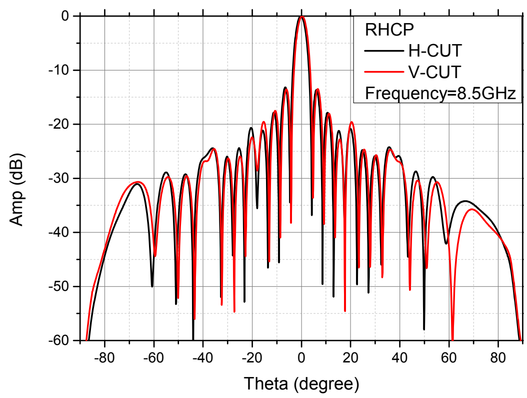

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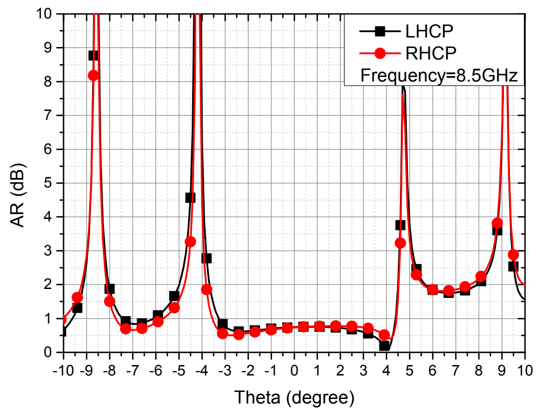

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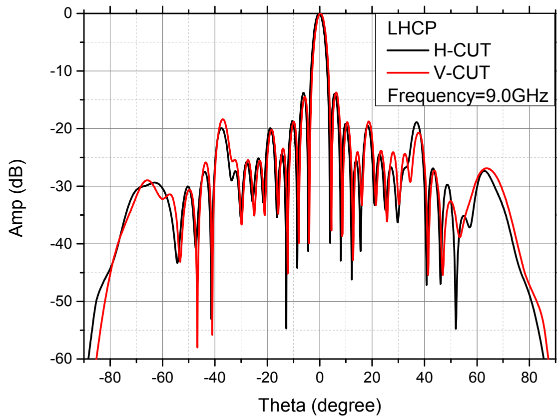
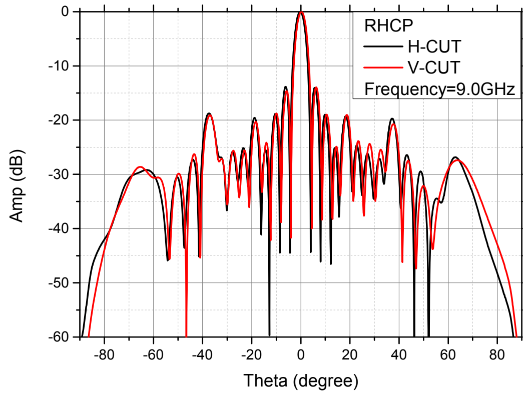
Fig. 5. Measured radiation pattern and axial ratio of the antenna at 8.5GHz for (a) LHCP and (b) RHCP, (c) axial ratio



(a)



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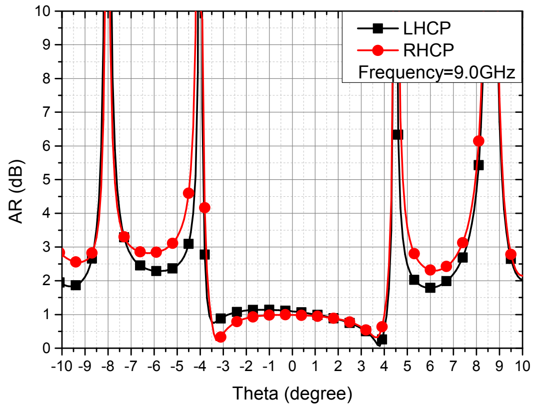

(c)

Fig. 6. Measured radiation pattern and axial ratio of the antenna at 9.0GHz for (a) LHCP and (b) RHCP, (c) axial ratio

IV. Conclusion

In this paper, the complete design and characterization of a waveguide horn antenna for X-band satellite communications (7.9-9.0GHz) were presented. This antenna can work as an on-the-move for satellite communication services, and its main advantages are its low profile, high efficiency and wide frequency band.

Measurements show that the maximum sidelobe level is less than -13dB, the radiation efficiency is above 80%, the axial ratio is below 1.5dB in the entire frequency band.

References

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