Design of a W-band Dual-polarization Monopulse Reflector Antenna

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Abstract **─** This paper introduces a W-band dual-polarization reflector antenna which combines one dual-polarized transmit-receive SUM channel and two single-polarized DIFF receiving channels. The feed of the antenna consists of four OMTs (Orth Mode Transducer) to realize dual-polarization monopulse angle measurement. Four horns of the feed are combined into one radiation aperture by a coupled retracted structure to decrease side-lobes. The SUM beam gain of the proposed antenna is over 41 dBi and the aperture efficiency of 60% is achieved, cross-polarization level is better than –43 dB. The first sidelobe level is better than -30dB. The null-depth is better than -20dB.

Index Terms **─** Dual-polarization, monopulse, reflector antenna, W-band.

I. INTRODUCTION

Fully-polarization radars have more advantages in target recognition and anti-jamming compared with single-polarization radars [1]. Many kinds of dual-polarization antennas have been proposed, such as microstrip patch [2], coupling slot [3], slot array [4], horn antenna [5] and reflectarray [6]. However in high-frequency band, waveguide slot array may have a high cost and is difficult to fabricate. And in high power applications, microstrip patch is not capable for its high dielectric loss.

The millimeter-wave dual-polarization detecting system requires a dual-polarized antenna with high gain and low side-lobes that makes reflector antenna a good candidate. Compared with other antennas working at w-band, the reflector antenna has the advantages of simple manufacturing, high gain, low side lobes, and narrow beams. The key component of a dual-polarization reflector antenna is a dual-polarization feed-source. In this paper, we proposed a dual-polarization reflector antenna with good radiation performance and easy approaching.

II. GEOMETRY AND ANALYSIS OF THE PROPOSED ANTENNA

According to the principle of focusing, the reflector antenna uses the reflection of the electromagnetic wave on the paraboloid to form a plane wave-front. The geometry of the reflector antenna system is illustrated in Fig. 1.

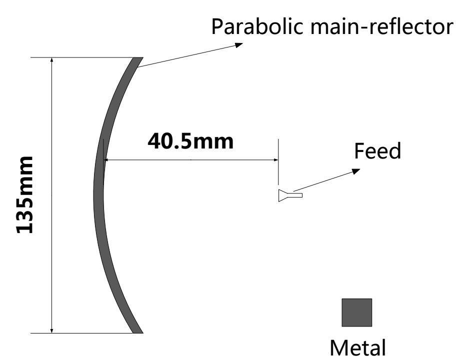

Fig. 1. Design and geometry of the antenna system.

The performance of the reflector antenna depends largely on the primary pattern of the feed, so the study of the primary radiation characteristics of the feed will benefit the overall antenna system. The proposed feed can be described in two parts, the feed net and four horns.

Figure 2 shows the working principle of the feed. In order to realize the SUM and DIFF signal processing, ports V1 and V2 receive and transmit vertically polarized wave while ports H1 and H2 receive and transmit horizontally polarized wave. Square waveguides 1, 2, 3 and 4 can transmit two kinds of orthogonal polarized waves. The sum of V1, V2 and the sum of H1, H2 make the dual-polarized sum signal of the proposed monopulse feed. The difference between V1 and V2 forms the pitch

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DIFF signal, and the difference between H1 and H2 forms the azimuth DIFF signal.

The feed takes the form of four receiving and launch ports to get rid of the complex design of the comparator, and replace the analog comparator with digital comparator. Therefore this design can eliminate the insertion loss caused by the analog comparator.

There are two ways to realize dual-polarization for horn feed, cross-slot coupling or application of OMT (Orth Mode Transducer). But the isolation between different polarizations of OMT is better than cross slot coupling. And the structure of OMT is easier to fabricate.

The structure of OMT and the feed is illustrated in Fig. 3, as is shown in Fig. 3 (a), the feed source consists of four OMTs. They are combined to a radiation aperture by a coupled retracted structure. Both polarizations of the OMT structure can receive and transmit the sum signal, but the pitch different signal can only be received by the DIFF channel of one polarization, while the azimuth different signal received by the DIFF channel of the other polarization.

The structure of OMT is illustrated in Fig. 3 (b), a metal bar is designed above the coupling slot to optimize the isolation between horizontal polarization and vertical polarization.

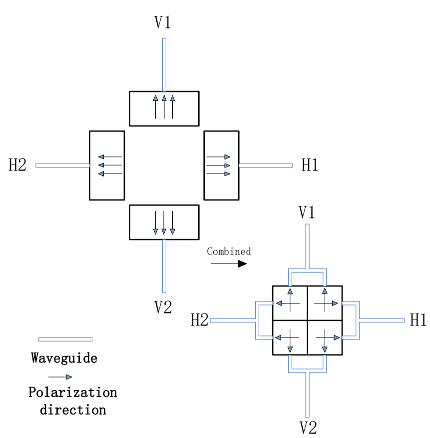


Fig. 2. Polarization direction of the feed.

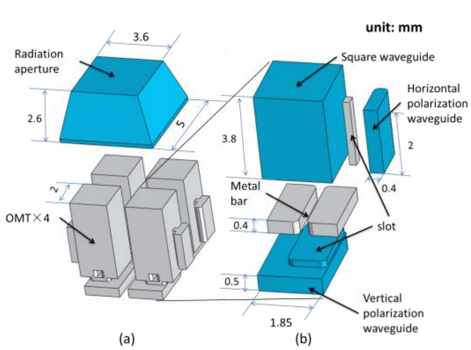


Fig. 3. (a) Structure of feed. (b) Structure of OMT.

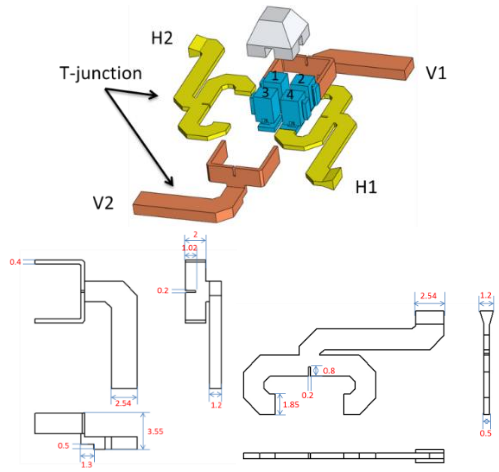


Fig. 4. Structure of the feed and the T-junction.

The structure of the feed is shown in Fig. 4, and it is the specific feed-source structure that realizes the working function shown in Fig. 2.

III. SIMULATION AND MEASUREMENT RESULTS

The simulated model is shown in Fig. 5, and Fig. 6 shows the prototype of the proposed antenna. The SUM pattern of the proposed antenna is illustrated in Figs. 7 (a), (b), and the DIFF pattern of the antenna is illustrated in Fig. 7 (b), where –M and –S represent measured and simulated result. (H) and (E) represent H-plane and E-plane. Isolation and VSWR of the feed ports are illustrated in Fig. 8.

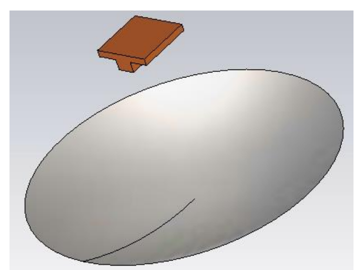


Fig. 5. Simulate model of the proposed antenna.

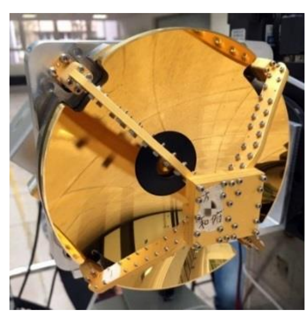
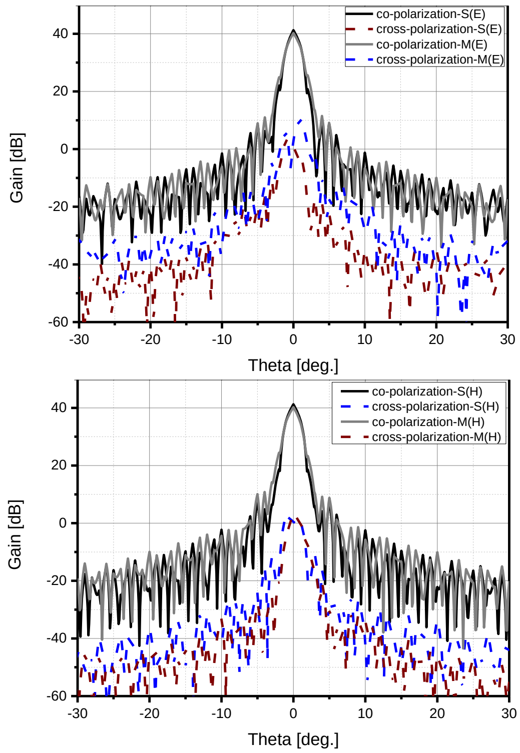
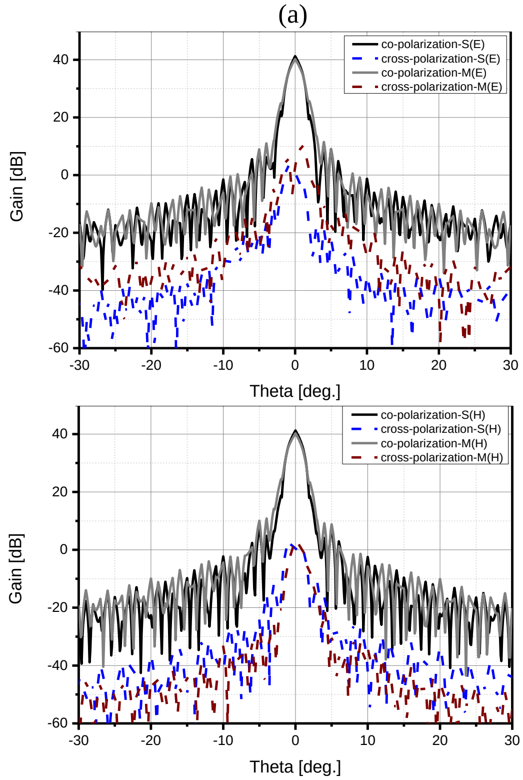


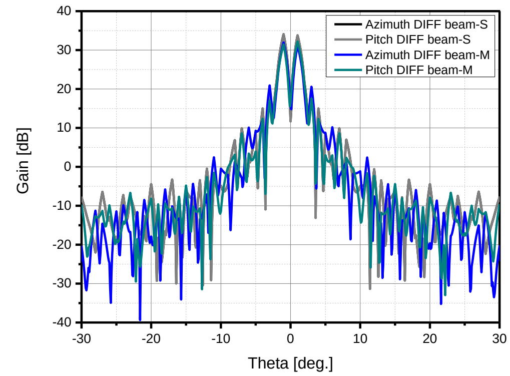
Fig. 6. Prototype of the proposed antenna.



(a)

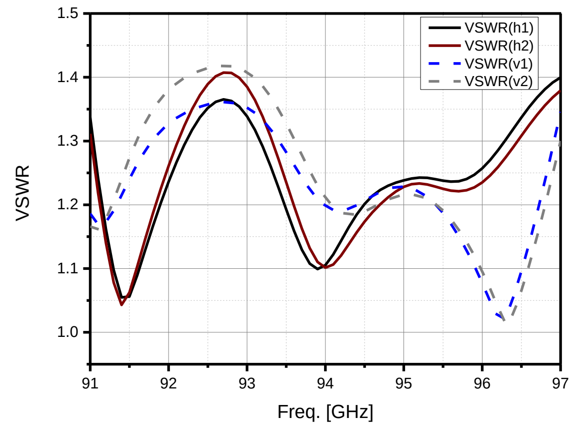


(b)

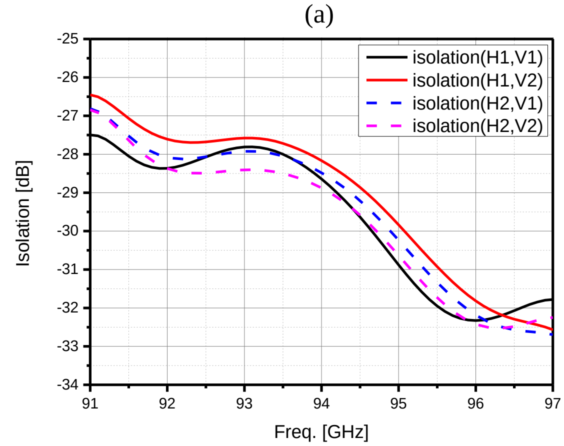


(c)

Fig. 7. (a) Vertical polarization SUM pattern. (b) Horizontal polarization SUM pattern. (c) Azimuth and Pitch DIFF pattern.



(a)



(b)

Fig. 8. (a) VSWR of the feed ports. (b) Isolation between different polarizations.

IV. CONCLUSION

In this paper, a dual-polarized monopulse reflector antenna working at W-band is demonstrated by employing a four-unit-horn with the OMTs as feed source. Simulating results verify that the polarization isolation is better than -30dB. The proposed antenna is designed and optimized in HFSS and CST. At 94GHz, the SUM beam gain is over 41dBi. Cross-polarization levels are better than -43dB and the first sidelobe level is better than -30dB. The null-depth is better than -20dB, the result reveals that the proposed antenna has excellent polarization synthesis and polarized monopulse performances further.

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