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Compact Fully Metallic Polarizer Integrated in a Geodesic Luneburg Lens Antenna

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Summary

In this paper, we present a polarizer design that is capable of rotating the linear polarization of a fully metallic geodesic Luneburg lens antenna. The polarizer is particularly suitable for applications where a compact design is needed. Our approach involves loading the radiating aperture of the antenna with two metallic screens, which enables the desired polarization rotation. The antenna design has been successfully tested in the K_a-band, covering the frequency range of 25 to 31 GHz with a bandwidth of approximately 20%.

1 Introduction

Antennas that are capable of beam scanning are essential for both terrestrial and satellite communication. In recent years, phased arrays have become the most commonly used solution for beam scanning, thanks to their low profile, flexibility, and affordability. However, at higher frequencies such as the millimeter-wave bands, the feeding network of phased arrays becomes increasingly complex and lossy. Therefore, researchers have turned to quasi-optical beamformers as a potential solution for antenna designs at higher frequencies [1].

Fully-metallic quasi-optical beamformers are of particular interest as they can be used to produce high-efficiency antenna systems. One promising beamformer solution is the geodesic Luneburg lens. A Luneburg lens is a rotationally symmetric gradient-index lens that transforms a point source at the edge of the lens into a planar wave at the diametrically opposite side of the lens [2]. It has been shown that a fully-metallic Luneburg lens can be implemented using curved parallel plates following a geodesic shapes [3].

For antennas used in mobile and satellite communication, polarization diversity is important. Circular polarization is important for satellite communication to overcome the problem with Faraday rotation and for mobile communication, having the possibility to use two orthogonal polarizations is crucial as it doubles the link capacity [4]. Achieving polarization diversity in fully metallic geodesic lens antennas is challenging since only the fundamental mode, a quasi-TEM mode is supported in the antenna, making it vertically polarized. Here, a compact and fully-metallic solution for achieving polarization diversity in a geodesic Luneburg lens antenna operating in the K_a-band is presented.

2 Fully Metallic Lens Antenna With Integrated Polarizers

Figure 1a presents a 3D model of the geodesic lens antenna designed in this work. The geodesic shape mimics the response of a Luneburg lens, and is obtained using the instructions outlined in [5]. The aperture of the antenna integrates two polarizer screens that rotate the vertical linear polarization of the quasi-TEM mode to a 45° slanted linear polarization while providing impedance matching to freespace. To achieve wide-angle performance, the polarizer screens are bent to conform with the aperture of the lens antenna. Two antennas with orthogonally slanted polarization can be stacked to provide polarization diversity. Standard waveguides feed the antenna, with eleven waveguides placed in 10° intervals, resulting in a scanning range of 100°.

A manufactured prototype of the integrated lens antenna is shown in Figure 1b. The prototype consists of two milled plates, which combine to form the lens, and two perforated aluminum sheets manufactured using water jet cutting.

Figure 1c presents the simulated and measured farfield results at 28 GHz for all eleven ports. The solid lines represent simulated results, while dashed lines represent measured results. A good agreement exists between the measured and simulated results.

Figure 1d shows the measured and simulated realized gain and polarization isolation for ports 6 and 11 from 25 to 31 GHz. The measurements indicate a slightly lower gain compared to simulations, likely due to losses from the surface roughness of the milled plates. Nevertheless, both the simulations and measurements show polarization isolation below -18,dB over the whole band and typically below -20,dB, showing that the polarizers operate well over a wide bandwidth and wide angular range.

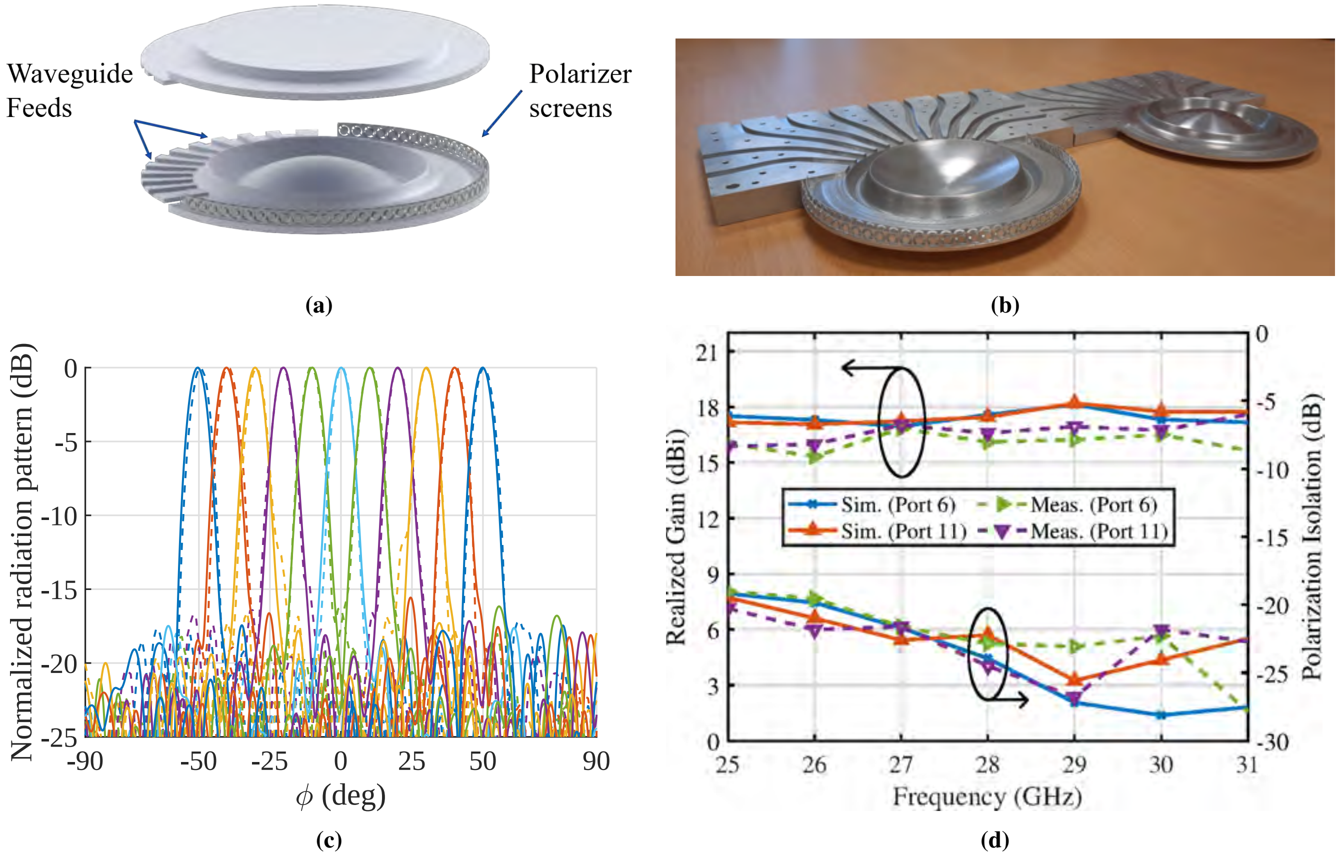

Figure 1. (a) 3D model of the integrated antenna design. (b) A photo of the manufactured prototype. (c) Normalized radiation pattern at 28 GHz for all eleven ports. (d) Simulated and measured results of the realized gain and polarization isolation for ports 6 and 11.

3 Conclusion

In conclusion, this work presents a fully metallic and compact solution for achieving polarization diversity in a geodesic Luneburg lens antenna operating in the K_a-band. Two polarizer screens are integrated into the flare of the antenna to rotate the polarization of the antenna. The polarizer work well over a wide bandwidth and since they are placed conformal to the aperture of the antenna they perform well over a wide-angle. The simulated and measured results demonstrate good agreement, with the antenna showing excellent polarization isolation and operating well over a wide bandwidth and wide angular range.

References

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