Direction Finding System Based on an Additively Manufactured Stackable Luneburg Lens

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Abstract — In this study, a 3D printed Luneburg lens-based direction finder was designed, manufactured, and tested. The paper discusses the material characterization process, followed by the design, construction, and finally the test of the prototype.

Keywords-Direction-of-arrival; Stereolithography.

I. INTRODUCTION

Direction of Arrival (DOA) estimation at microwave frequencies is important in many sensor applications such as wireless communications [1]. There are two known techniques used for DOA estimation [2]: the amplitude comparison which is wideband, low cost and portable but has low accuracy [2], and the phase interferometer system with high accuracy but is expensive and complex. Therefore, a DOA estimation system that is at relatively low cost, portable and possesses high accuracy is highly desirable in many applications. In this study, this will be achieved through a 3D printed stackable Luneburg lens.

II. LENS DESIGN AND MANUFACTURING

A Luneburg lens is a gradient index device in which the refractive index gradually changes inside the material [3]. The l variation in the permittivity profile of the lens is achieved by placing air inclusions in the base material, lowering the base permittivity to the required value [4]. The final design is shown in Fig. 1.

The lens was manufactured out of Acrylonitrile Butadiene Styrene (ABS) using Stereolithography (SLA) technology, which presented a dielectric constant of 3.07 at 1.5 GHz, and had finer details with an accuracy of ±0.01 mm. The manufactured lens is shown in Fig.1.

II. EXPERIMENTAL VALIDATION

A first test of the functionality of the lens was performed in an anechoic environment. A receiving antenna was placed at the Zeroth position of the lens. A transmitting antenna was placed at a constant radial distance and the relative angle between the transmitting antenna and the Zeroth position was varied between +- 45’. The received power per angle of arrival was measured. As comparison, the same test was performed removing the lens.

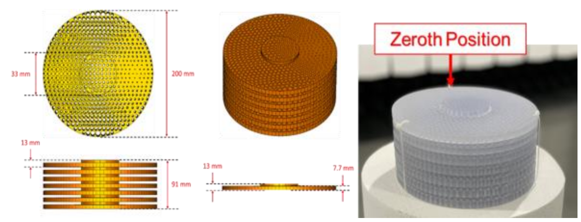

Figure 1. From the left to right: The constructed design of the Luneburg lens, manufactured and aligned final lens prototype. Notice the Zeroth position of the lens

The results presented in Fig. 2 shows that the power received maximizes when the relative angle coincides with the Zeroth angle of the lens, showing the capability of this device in identifying this angle of arrival.

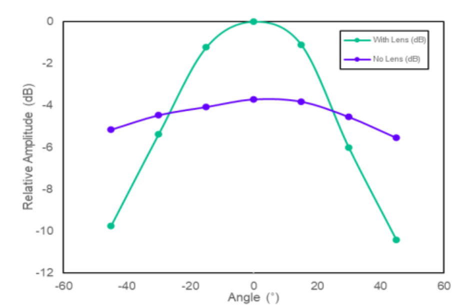

Figure 2. Relative amplitude measured at different angles of arrivals with and without lens. Notice how the lens maximizes the received power when the angle of arrival and the position of the lens coincide.

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