

Modeling of a G-band modified geodesic lens antenna using a ray-tracing technique

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The Luneburg lens is a graded index lens that transforms a spherical wave into a planar wave [1]. This lens can be used in a multibeam antenna with the attractive property that scanning can easily be done by moving the feed, and because of the rotational symmetry of the lens, scan losses can be small. The Luneburg lens antenna is usually implemented by discretizing its refractive index into several dielectric layers [2], using metasurfaces [3], or geodesic lenses [4]. A geodesic lens mimics the behavior of a planar graded index lens by appropriately shaping a parallel-plate waveguide (PPW) structure [5]. The resulting non-flat PPW avoids the use of dielectric materials, which are known to cause relevant material losses at high frequencies. As a result, the antenna design based on a geodesic lens can achieve high efficiency.

However, at high frequencies, the integration of these lenses with the rest of the system could require long waveguide feeds, which can deteriorate the radiation performance of the antenna [6]. The Gutman lens [7] can have a smaller focal distance than the Luneburg lens, and its focal arc can in many practical scenarios be approximated by a flat surface without prohibitive performance degradation. This can allow for shorter feeding waveguides which can alleviate the integration of the lens antenna in systems. Alternatively, transformation optics (TO) lenses [8] can be used to design lens antennas with a flat focal surface. However, these lenses are also subject to approximations to achieve a planar focal surface. Furthermore, Gutman and TO lenses have been implemented using dielectric or artificial materials, which can introduce significant losses. Here, we propose a geodesic lens antenna with a flat focal surface. This design is done using an in-house ray-tracing model that has been developed for the development of arbitrary geodesic lens antennas [9]. This ray-tracing model allows for a fast design of the geodesic lens profile. Our geodesic lens antenna operates in the G-band and demonstrates improved efficiency compared to the reference cases since dielectrics are avoided. This lens antenna can be easily integrated into the overall system by using short waveguide feeds.

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