Multi-beam Antennas Based on Modified Luneburg Lens

Muhammadeziz Tursunniyaz*, Hung Luyen, John Booske, and
Nader Behdad
Department of Electrical and Computer Engineering
University of Wisconsin, Madison, WI, 53706, USA

High gain, multi-beam reconfigurable antennas are highly desired for overcoming propagation losses at millimeter-wave band for the next generation communication systems. Luneburg lenses are widely used for high gain multi-beam antenna implementation due to its rotational symmetry. Both two-dimensional (2D) and three-dimensional (3D) Luneburg lenses have been reported in the literature. Because they require a dielectric constant gradient, achieving the required effective dielectric constant profile with commercially available materials is challenging. Researchers have implemented the 2D Luneburg lens with parallel plate waveguides by gradually changing the plate separation to achieve required effective dielectric constant. Dielectric slabs have also been used as Luneburg lenses, achieving gradients in the effective dielectric constant by drilling holes through the slabs. Most recently, metamaterials have been used for designing planar Luneburg lenses. Typically, these prior approaches have used a full Luneburg lens, which makes them bulky.

In this presentation, we report a planar multi-beam antenna based on a modified Luneburg lens (A. S. Gutman, J. Appl. Phys. 25, 855 (1954)). Since the focal distance of this lens is half of its radius and the overall thickness of the lens, including feeds, is $0.635\lambda_0$, our design is low profile and more compact than designs previously reported in the literature. Our proposed multi-beam antenna is capable of wide angle beam scanning in the azimuth plane ($\pm 60°$). We used the dielectric slab material C-STOCK AK with $\epsilon_r = 5$ and $tan\delta = 0.002$ from Cuming Micrwoave Corporation for the lens and tapered its thickness along its radius to achieve the desired effective dielectric constant profile. The radius of the modified Luneburg lens is 130 mm, and its thickness is 12.7 mm at the center and 1.58 mm at the edge. The lens is fed with dielectric filled waveguides tapered along the E-plane for good impedance matching. Seventeen feeds separated by 7.5°, were positioned along the focal arc of the lens. Our simulation results predict that the center feed should have a gain of 19.2 dBi, with a 3 dB beamwidth of 6° in the H-plane and 33.1° in the E-plane. Since there is no reliance on drilling holes, this design can be straightforwardly scalable to higher frequencies. We will present and discuss details of the design process and the measurement and simulation results at the conference.