A New 3D-Printed Electronically Scanned Spinning Spot Beam Inhomogeneous Dielectric Lens Antenna for Spaceborne Wind Scatterometer Weather Radar Satellites

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Weather radar instruments have shown chronic failure due to moving mechanical parts wearing over time. These current systems achieve a conical beam scan by rotating a parabolic reflector antenna by mechanical means. New designs should avoid moving parts and transition to a full electronic version while maintaining similar performance. In this paper, a new all electronic spinning spot beam weather radar antenna for spaceborne wind scatterometers is presented.

The antenna is designed through our novel algorithm based on a combination of Geometrical Optics (GO) and the Particle Swarm Optimization (PSO) method. The GO method can trace rays through inhomogeneous media and calculate the amplitude, phase, and polarization of the electric field quickly. The complex engineered material lenses that result are printed using 3D printing techniques. The synthesis technique is first used to obtain an on-axis fed low mass 30cm diameter inhomogeneous design. The design is evaluated through Full-Wave simulations and through measurement and excellent agreement is obtained. The synthesis technique is then used to generate an off-axis fed scanned beam design with low mass at the same diameter of 30cm. Imposition of a Body-of-Revolution restriction allows the optimization, which is performed at a single offset feed location, to then produce identical scan performance for all azimuthal scan angles and hence produce a spinning spot beam.

Simulation results for the scanned beam design show a high-directive beam scanned to a wide angle. The scanned beam design has comparable directivity to that of the broadside beam design. UV-space beam layout plots verify this beam performs a conical beam scan sweep. The pattern remains the same for all azimuthal angles. Both our 30cm on-axis and off-axis fed lens antennas achieve a reduction of volume of approximately 75% over that of a Luneburg lens with a 30cm diameter. We also present a possible circular feed array to place along the circular ring focus of the lens antenna to excite the beamlets in the sweep, all electronically.