

ABSTRACT

In the rapidly evolving field of Ku-band satellite communications, the development of compact, high-gain antenna arrays with stable circular polarization is essential for next-generation broadband services. Despite this need, few investigations have incorporated metamaterial lenses into scalable microstrip arrays with empirical validation. This study details the conception, fabrication, and experimental assessment of a 64-element circularly polarized microstrip array enhanced by a split-ring resonator (SRR) metamaterial lens. A four-phase approach was employed: extraction of design criteria for SRR-augmented microstrip elements through an exhaustive literature survey; electromagnetic simulation and refinement of corner-truncated patch elements with SRR overlays using HFSS/Ansys to secure circular polarization and peak directivity; construction of prototypes on Duroid 5880 substrates and measurement of return loss, axial ratio, and gain; and formulation of a scaling framework, based on single-element and small-array simulations, to forecast full-array performance. The incorporation of a Double Split-Ring Resonator (DSRR) metamaterial lens into a 64-element array antenna substantially improves its electromagnetic performance. Simulated outcomes demonstrate a peak gain of 37.1 dBi, return loss of -18.421 dB, and an axial ratio of 2.38 dB at 12.56 GHz. Validation through experimental fabrication confirmed a measured gain of 35.89 dBi. The DSRR-enhanced array exhibits an average gain increase of approximately 11.7 dB and a notably narrower beamwidth, though this improvement is accompanied by a reduction in operational bandwidth. Overall, these findings highlight the DSRR metamaterial lens as an effective technique for achieving high-gain, circularly polarized antenna systems suitable for advanced satellite communication applications.

Keywords: Metamaterial, Antenna Microstrip, Split-Ring Resonator (SRR) metamaterial lens, Ku-band satellite communications, High-gain scalable array design.