

Dual-Band, Dual-Circularly Polarized Metasurface Antenna for K- and Ka-Band

Ravikanth Thanikonda, Alberto Toccafondi, Enrica Martini, *Senior Member, IEEE*, and Stefano Maci, *Fellow, IEEE*

Department of Information Engineering and Mathematics, University of Siena, Siena, Italy
e-mail: ravi.thanikonda@student.unisi.it, albertot@dii.unisi.it, {martini, macis}@diism.unisi.it

In the rapidly evolving field of space communications, dual-band and dual-circularly polarized antennas have emerged as transformative technologies, offering expanded beam coverage and enabling simultaneous uplink and downlink operations. Modern communication systems demand antennas with dual-band capabilities, low-profile designs, cost-effectiveness, precise polarization control, and high efficiency. Metasurface (MTS) antennas have risen to meet these challenges by leveraging engineered metallic textures on thin grounded dielectric slabs to create modulated impedance boundary conditions (IBCs). These IBCs enable precise control over radiation patterns and polarization, as demonstrated in foundational studies (M. Faenzi, G. Minatti, D. Gonzalez-Ovejero, F. Caminita, E. Martini, C. Della Giovampaola, and S. Maci, “Metasurface antennas: New models, applications and realizations,” *Scientific Reports*, vol. 9, 07 2019).

Recent advancements have explored dual-polarized MTS antennas at Ka-band using triaxial feeding systems and inward-outward surface wave duplexing (R. Thanikonda, M. Faenzi, A. Toccafondi, E. Martini and S. Maci, “Dual Circularly Polarized Metasurface Antenna Based on Inward and Outward Surface Wave Duplexing,” in *IEEE Transactions on Antennas and Propagation*, doi: 10.1109/TAP.2025.3529257). Additionally, wideband MTS designs have been proposed to overcome bandwidth limitations by exponentially stretching the impedance modulation period, creating an annular active region that shifts with frequency (M. Faenzi, D. González-Ovejero and S. Maci, “Wideband Active Region Metasurface Antennas,” in *IEEE Transactions on Antennas and Propagation*, vol. 68, no. 3, pp. 1261-1272, March 2020, doi: 10.1109/TAP.2019.2940365). Furthermore, dual-frequency MTS antennas with dual-layered configurations have been developed for independent operation at widely separated frequencies (K. Hecht, N. Chahat, G. Chattopadhyay, E. Martini and M. J. Mencagli, “Dual-Frequency Metasurface Antenna for Earth Science Remote Sensing,” 2024 18th European Conference on Antennas and Propagation (EuCAP), Glasgow, United Kingdom, 2024, pp. 1-4, doi: 10.23919/EuCAP60739.2024.10501030.). However, a critical gap remains in the study of dual-pole, dual-band MTS antennas operating across a 10 GHz frequency separation, particularly in the K- and Ka-bands.

This article presents a novel dual-pole, dual-band MTS antenna solution that builds upon the concepts introduced by Thanikonda et al. (*IEEE TAP*, 2025). The key innovation lies in the implementation of a duplexing technique that leverages both outward and inward surface waves operating at dual frequencies over a shared modulated MTS aperture. This approach enables the simultaneous generation of dual-polarized broadside beams through combined inward and outward wave excitations, offering precise control over polarization states. A single MTS aperture capable of producing broadside radiation at both K- and Ka-bands will be demonstrated, alongside a novel feeding structure and an innovative MTS design. The proposed solution stands out for its simple feeding mechanism, low-profile architecture, moderate losses, and exceptional versatility in controlling radiation pattern polarization. These features make it a promising candidate for next-generation space communication systems requiring dual-band and dual-polarized operation.

“R. Thanikonda gratefully acknowledges the support of the National operational programme (NOP) on research and innovation 2014-2020, Line IV.4.”.