

# Fully Metallic Reflectarray Unit Cell for Independent Control of Dual Circular Polarization

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In recent decades, reflectarrays have established themselves as an innovative class of high-gain antennas, combining various advantageous features of reflectors and arrays, while also offering an alternative design characterized by a reduced profile and lower weight. These antennas stand out due to their low mass, compact profile, and ease of manufacturing, attributes that make them particularly suitable for space applications, alongside their high efficiency and gain capabilities. A key advantage of reflectarrays over traditional reflectors lies in their ability to precisely control the phase of each element within the aperture. This enables the optimization of scanning performance without incurring additional costs or the distribution losses associated with the feeding network of large arrays.

In recent years, the potential of reflectarrays in the design of advanced multibeam antennas has been extensively investigated (E. Martinez-de-Rioja et al., “Advanced multibeam antenna configurations based on reflectarrays: providing multi-point coverage with fewer apertures for satellite communications in the *K*- and *Ka*-bands,” *IEEE Antennas and Propagation Magazine*, vol. 61, no. 5, pp. 77-86, October 2019). However, most designs are based on grounded dielectric substrates with metallic patterns, which face limitations for satellite deployment, due to the harsh space environment, including extreme temperature variations and cosmic radiation. In contrast, fully metallic reflectarrays provide advantages such as reduced thermoelastic distortion, leading to stable performance throughout a satellite's operational lifespan. Although research on fully metallic reflectarrays is less developed compared to their dielectric counterparts, they offer comparable performance potential and are increasingly seen as a more suitable option for satellite applications. Another important feature of reflectarrays is the capability to independently control different polarizations. To this end, a number of dual linearly polarized unit cells have been proposed. Most satellite applications, however, use circular polarization, thus, requiring the use of an additional layer to perform polarization conversion.

This article presents the design of a simple *Ka*-band fully metallic unit cell combines the geometric phase principle, also known as the Pancharatnam-Berry phase, and a proper geometry variation to achieve independent phase control of two circular polarizations. A similar principle was recently exploited to design a unit cell consisting of a branch line coupler and a square patch printed over a grounded dielectric slab (C. Fang, X. Zhang, Y. Li, T. Yuan, Z. Quan and S. -W. Wong, "Dual-Circularly Polarized Reflectarray Based on Polarization Selectivity of Single-Fed CP Antenna Element," in *IEEE Transactions on Antennas and Propagation*, vol. 73, no. 1, pp. 647-652, Jan. 2025). Full-wave simulations were performed using the Floquet mode analysis tool available in the commercial electromagnetic software CST Microwave Studio®. Additionally, normal incidence on the structure was considered. The unit cell geometry, which will be presented at the conference, consists of a concentric ring with a maximum radius  $R_0 = 1.8$  mm and a period of  $p = \lambda/2$ . The phase difference of  $180^\circ$  between the TE and TM modes, essential for achieving geometric phase control of the structure, is obtained through the design of four slots (opposite one another) positioned at the edge of the concentric ring. Different combinations of the slot depth ( $h$ ) and width ( $w$ ) allow for the creation of a database that provides a full  $360^\circ$  phase excursion for both circular polarizations. With this database and adherence to the geometric phase principle, it is possible to design fully metallic static reflective metasurfaces capable of generating two independent beams with different polarizations in azimuth and elevation, respectively. The results of different reflectarray configurations will be presented at the conference.