Reflective metasurface for simultaneous generation of Fronthaul and Backhaul Links in mm-Wave FR2 communications

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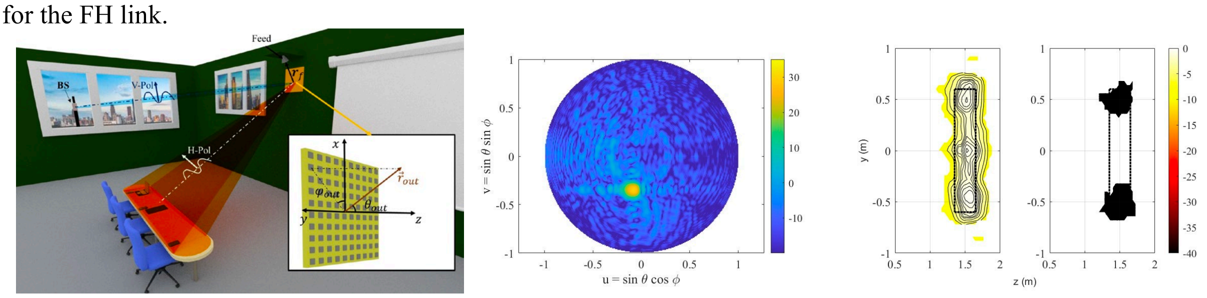
The utilization of mm-Wave spectrum is gaining interest with the advent of the 5G and upcoming generations like 6G, aiming to provide high-speed wireless access in cellular networks. These systems are anticipated to operate in frequency bands from 20 to 300 GHz, increasing the capacity of the system and reducing the latency compared to their predecessors. The use of mm-Wave spectrum in communication poses novel challenges concerning signal propagation characteristics [1]. Higher frequencies result in faster signal attenuation (increased path loss) and greater susceptibility to physical barriers, as the penetration losses become more prominent. In outdoor scenarios such as streets, the coverage provided by a base station (BS) may be disrupted by densely populated areas with numerous buildings, whereas indoor scenarios (shopping malls, airports, and so on) may experience coverage limitations due to obstructions like walls or furniture. Consequently, these factors give rise to areas with inadequate or nonexistent coverage, commonly known as blind zones. A low-complex and cost-effective solution involves deploying femtocell BS that are specifically adapted to the blind zone. In this scenario, the BS would generate a fronthaul (FH) link that covers the blind zone. However, the BS still requires a high-capacity backhaul (BH) link, typically implemented through wired solutions (i.e., optic fiber). As a result, this deployment can become expensive due to the need for costly BH infrastructure. In this line, a common approach is using Reflective Intelligent Surfaces (RIS). However, existing RIS implementations primarily focus on tilting the FH link, especially the RIS-1 and RIS-2 [2].

In this work, a reflective quasi-periodic surface is proposed to enable simultaneous deployment of both links, by operating in dual-linear polarization in Ka-band. The reflective surface reflects the incident field (provided by a primary feed) in one linear polarization to radiate a high-gain beam directed towards another BS to facilitate the BH link. In contrast, the reflective surface is especially designed to generate a shaped pattern for comprehensive coverage within its near field region, taking into account the distance to users and the antenna aperture size in a femtocell. To do so, the FH is achieved through a technique called Near-Field Phase-Only Synthesis (NF-POS), while the BH link is analytically determined. To operate in dual-linear polarization the unit cell consists of a dual-layer stacked configuration of orthogonal dipoles, which allow independent control of each polarization and ensures high isolation between the orthogonal polarizations. The reflective surface undergoes manufacturing and evaluation processes in an anechoic chamber and a planar acquisition range to obtain a thorough characterization of its radiation patterns. The measured results align closely with the simulated data, demonstrating the successful implementation of a reflective-based surface BS capable of establishing an FH/BH link in the Ka-band. Furthermore, to the best of the authors' knowledge, this prototype represents the first implementation that considers simultaneously both far and near field constraints, considering a shaped beam rather than a focused one for the FH link.



(a) **(b)** **(c)**

Figure 1. (a) Sketch of the proposed scenario and technique (b) Prototype at the anecoich chamber (c) Measured radiation pattern.

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2. E. Martini and S. Maci, "Theory, Analysis, and Design of Metasurfaces for Smart Radio Environments," in Proceedings of the IEEE, vol. 110, no. 9, pp. 1227-1243, Sept. 2022.

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