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Novel Rotman-Lens-based Beamforming Networks for Hybrid Near- and Far-field Multi-beam Radiations with Distinguished Selection Ports

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Near-field communication and sensing are booming, and will produce significant civilian markets. Examples include biomedical sensing, hand gesture detection and vehicular anti-collision radar systems. The have a trend to hybridize with the conventional far-field communication and radar systems. Multi-beam antennas are very attractive due to their capability of different radiation characteristics for each beam. The design of such multi-beams of distinguished radiation behaviors is very challenging to produce a proper beamforming circuit. Conventional approaches of Butler matrix, Rotman lens and Luneburg-lens-based beamforming circuits are generally developed to produce far-field mult-beams of similar beamwidths in different beam directions. Near-field multi-beam designs were also studied with angular spot beam separation. The hybridization of near-, far-field or even contoured radiation patterns provide convenient applications to simultaneously fulfill the modern communication and radar sensing systems.

In this paper, we will present the basic concepts of near- and far-field beam radiation hybridization. A useful beamforming circuit is presented to demonstrate the possibility of achieving the multi-beams of near- and far-field focusing capabilities. The demonstration further considers the hybridization of near-field contoured beams and far-field pencil beams for showing the application flexibility. The proposed conceptual realization is based on the geometric optics (GO) ray deviations to produce the defocusing excitations phases on the Rotman lens beamforming circuit designs. These effective ray deviations deform the conventional Rotman lens design into a general beamformer a variety of excitations to feed phased arrays of antennas which may have equally or unequally spaced positions for radiation optimizations.

Conceptual equations to design the new Rotman lens will be presented. Characterization criterions are defined and presented to show the basic behaviors. A practical application to vehicular anti-collision radar systems to provide narrow field of view (FoV) in the vehicles' broadside and broad shaped beams to cover the lateral regions is shown to validate the feasibility. Numerical simulations and experimental measurements are shown to exhibit the radiation characteristics.