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Multiple OAM Modes Based on a Fisheye-Lens Beamforming Circuit

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Antenna radiations with orbital angular momentum (OAM) modes have received much attention for their potentials to enhance spectrum efficiency and system capacity [1, 2]. The spectrum efficiency enhancement mechanism is based on the orthogonality between different OAM modes. OAM radiations can be produced by array configurations and various antenna types, including reflectors, reflectarrays, and phased arrays of antennas, among which phased arrays of antennas are the most flexible for their dynamic excitations. These OAM modes are conventionally produced by exciting a uniform circularly spaced array of antennas with cylindrical wavefront phases, which has a narrow frequency bandwidth. The Hankel transform can interpret the radiation characteristics. Potential applications include 5G/6G MIMO and radar systems.

This work introduces a fisheye-lens-based beamforming circuit (FL-BFC) to excite an antenna array to generate seven-mode OAM radio beams. This FL-BFC is more compact in size and has relatively dynamic multi-mode phase outputs. Relatively flexible phase outputs can be achieved by properly selecting the proper positions of output ports on the FL-BFC, which has a broad frequency bandwidth. As a result, the restriction of uniformly spaced array configurations can be relaxed, allowing the array format to vary from non-uniformly spaced arrays to that in a spiral configuration. This relaxation may benefit the reduction of null regions resulting from different OAM modes due to the uniform circular arrays to increase the coverage area.

A realistic OAM antenna array in a spiral configuration is presented to validate the multi-mode concept by full-wave simulations using HFSS and radiation measurements over antenna prototypes. With the help of the OAM spectrum, the Envelope Correlation Coefficient (ECC) is used to study the mode purity and inter-mode orthogonality [4]. Both full-wave simulation and measurement results will be shown to validate the design concept.

References

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