

Superdirective Sectoral Circular Phased Array of Huygens Dipole Antennas

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Circular phased arrays (CPAs) have facilitated numerous acoustic and electromagnetic (EM) applications over several decades. They can readily provide omnidirectional coverage in both transmission (e.g., broadcasting – information dissemination) and reception (e.g., sensing – information capture) modalities. As phased-array systems, they are attractive for use in multifunction radar and communication applications. In comparison to planar arrays, the scan-invariant azimuthal beams of CPAs have several attractive properties. These include their directivity, beamwidth, sidelobe level (SLL), and polarization purity, which remain relatively constant as the scan angle changes. Moreover, they offer the ability to combine both their omni and directional properties in a single, simple system, and their directive beams can be scanned with uniform behavior over the entire 360° azimuthal space.

CPAs are typically formed with vertical electric dipoles. The resulting vertically-polarized (VP) fields experience significantly lower attenuation losses compared to horizontally polarized (HP) fields when an electromagnetic wave propagates over a lossy medium, such as the Earth. Thus, they are employed in many modern wireless systems, such as WLAN routers and intelligent transportation systems. However, as we move to higher frequencies to facilitate high data transfer rates, propagation losses are larger and higher directivity systems are becoming the facilitators of those applications.

It has recently been demonstrated that employing VP Huygens dipole antennas (HDAs) as the elements in both full and sectoral uniform circular arrays (UCAs) can significantly enhance their directivities (R. W. Ziolkowski, “Superdirective circular arrays of electric and Huygens dipole elements,” *Electromagnetic Science*, vol. 2, no. 1, article no. 0050072, Mar. 2024). In fact, superdirective versions of small-radius, phased sectoral UCAs were demonstrated that exhibit unidirectional, high front-to-back ratio (FTBR) radiated fields. The Bessel-azimuthal multipole (BEAM) approach developed therein was based on an eigenbeam (multipole) decomposition of the radiated fields and was used to specify their excitation amplitudes. This optimization approach and the consequent superdirective UCAs will be briefly reviewed in our presentation.

Moreover, based on the UCA expertise and system developed in (G. Wei, Y. Wang, Y. He, R. W. Ziolkowski, and Y. J. Guo, “Ultra-wideband vertically-polarized long-slot circular phased array,” *IEEE Trans. Antennas Propag.*, vol. 72, no. 5, pp. 4161–4172, May 2024), we are designing a HDA-based superdirective sectoral CPA demonstrator. The practical issues involved will be discussed. Current simulation studies indicate that such a system is realizable. A simulated directivity of 10.39 dBi and a realized gain of 10.01 dBi have been obtained already for a 15-element radially-directed HDA-based 144° wide sector CPA whose radius is $1.2 \lambda_0$. These values are greater than the theoretical maximum directivity of a three-dimensional array having the same equivalent area, i.e., 9.50 dBi, showcasing its superdirective performance. We aim to have experimental verification of these concepts and approaches at the conference.