Overcoming the Limitations of Beam-Bandwidth Product using RF Photonic Arrays

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ABSTRACT

This paper introduces a new paradigm for the design, development and application of broadband, multi-functional RF antenna systems. The objective is to emulate the principles of human vision in the realization of a new generation of antenna systems, namely those whose performance is based on spatial perception, i.e., *seeing*. Moreover, once spatial perception is achieved, integration with software-defined digital systems enables simultaneous, multi-functional operation within each spatial sector over extremely broad bandwidths, all within a small, laminate-scale, form factor. This is achieved using *spatially-coherent* optical up-conversion that relies on an RF-photonic feed network to perform real-time, massive beam-space processing. This approach decouples beam-space processing from signal-space processing and thereby enables unlimited beam-bandwidth-products for RF array antennas. Consequently, simultaneous multi-functional operation can be achieved within each spatial sector, over extremely large instantaneous bandwidths and over wide operational frequencies. On the receive side, such performance is achieved by phase-locking a single laser across every element in the array antenna and immediately performing an up-conversion on every incoming broadband RF signal, *before detection and digitization*. Subsequently, every RF-to-optical sideband is gathered into a common fiber bundle/array and a Fourier transform lens is used to perform real-time, *massive* beam-space processing. This approach directly emulates the spatial processing of human vision and does so without the need for any digital processing in the *spatial* domain. Once formed, each spatially processed beam can be down-converted directly to baseband, or a suitable intermediate frequency, for processing in signal-space. On the transmit side, a complementary RF-photonic approach is used to implement a *spatially- and temporally-coherent* waveform across the array that embodies a true holographic representation of the desired RF radiation waveform and pattern. Upon transmission, each RF beam is rendered as a direct consequence of the hologram and can contain unique and independent functionality. A system design is presented along with a full demonstration of transmit and receive phased array implementations.