An Electrically-Large and Multiply-Fed Holographic Antenna Based on Waveguide-Fed Metasurfaces

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Shared aperture antennas exist which span an electrically-large area and simultaneously exhibit multiple characteristics. For example, a phased array may include dual-band or dual-polarized elements and shift between the two operations as desired. Alternatively, the array may have a subset of elements dedicated toward a particular function while other elements have a secondary purpose. In the case where each element can operate with multiple functions there is added complexity associated with each antenna element, while in the case of the interleaved array the designer has to work around the thinned-array problem. Another method to achieve a multifunctional array is with a holographic metasurface antenna. Whereas the other methods tend to utilize a separate Tx/Rx module for each element in the array, a metasurface antenna can distribute the signal across a large area with a single injected waveform. Extended to a multiport antenna, holographic metasurfaces can be designed to multiplex several functions from the same compact platform with the opportunity to adaptively switch between modalities at will.

One common metasurface architecture that can operate toward this end is a *waveguide-fed* or *cavity-backed* metasurface aperture. Such antennas employ an electrically-large waveguide (e.g. a microstrip in 1D or parallel-plate waveguide in 2D) which is interrupted with radiating elements etched into its boundaries. These elements may be tailored metamaterial resonators or include simple geometries such as those employed in slotted-waveguide antennas. For the case where the waveguide mode is reflected at the aperture boundary before depletion, the transition from a waveguide to cavity mode is possible. This may offer distinct advantages in terms of the coupling from the feed to the radiative elements. Achieving the correct phase profile at each radiating element is akin to designing a computer-generated hologram, and entails solving for the underlying feed wave as well as the interactions of the elements. If implemented correctly, this holographic platform may allow for the emission of multiple wavefields with varied characteristics as set by the desired application. Such performance is of interest within hybrid analog-digital beamforming for use in both radar and wireless communications. We will highlight how such a structure can be designed and modeled, followed by a discussion as to the trade-offs associated with various flavors of multiplexed holographic antennas.