2D Flat Lens Antenna Based on Metamaterials Printed Elements

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2D Lenses are devices which transform a plane wave (PW) to a cylindrical wave (CW), and vice versa. In microwaves, the main purpose of a lens is to enhance the directivity of the antenna. Conventional lenses are usually made of a dielectric material with constant permittivity and varying external contour, which compensates for the phase error caused by the CW propagating from the focal point to the lens aperture and obtain a uniform phase distribution over the lens aperture.

Since the conventional lens is bulky with somewhat complicated geometry, it is desirable to use a flat and thin lens with comparable focal length and aperture size. The most obvious way to design a flat lens is to use an inhomogeneous dielectric material with a continuous dielectric constant function, which can compensate for the phase error distribution caused over the lens aperture by the cylindrical wave propagating from the focal point to the lens aperture. Realization of such a design is difficult and quantization of this dielectric constant function introduces phase errors which downgrades the lens radiation performance.

The alternative is to use metamaterials technology to obtain the required phase correction over the lens aperture. Metasurfaces are the 2D version of metamaterials technology and are designed as planar periodic structures with unit cell size of less than 0.1λ. In case of printed elements in the unit cell, the metasurfaces can be characterized by the homogenization method as surfaces with effective tensor surface impedance (A.M. Patel and A. Grbic, IEEE Trans. Ant. and Propagat, 61, 1, 211-220, Jan. 2013). The effective tensor surface impedance can be obtained by two orthogonal polarization reflection measurements from the metasurface. This modelling of the metasurface enables to compute easily the complex transmission coefficient through a multilayer metasurface structure using transmission line theory for the basic Floquet mode instead of using full wave analysis. Careful design of the unit cell printed element enables to control the phase of the transmission coefficient and keep its magnitude close to unity. This phase can be used to compensate the phase errors on the lens aperture and obtain almost uniform phase distribution with uniform magnitude in an easily and ordered procedure. Comparison between conventional lens and multilayer metasurface flat lens will be presented at the symposium.