Dual-band modulated metasurface antennas

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During the last decade, metasurface (MTS) antennas have sprung up for a wide range of applications. Among their advantages it is worth noting their capability of providing high to very-high gains, shaping the beam, and a simple on-surface control of the aperture fields, all this while keeping a low profile and low weight. The two latter features are particularly appealing for deep space communications. The operating principle of MTS antennas is based on the interaction between an (equivalent) inductance tensor and a (dominantly) transverse magnetic (TM) surface-wave (SW) on the antenna aperture. By adequately modulating the reactance tensor, the (-1) indexed Floquet mode can be pushed into the visible region and, hence, one can gradually radiate the SW power. The modulation of the surface reactance is implemented in the microwave range by changing the size and orientation of sub-wavelength patches printed on a grounded dielectric substrate, and arranged in a periodic lattice. Therefore, the resulting structures are easy to manufacture and their fabrication cost is lower than that of reflector antennas. Moreover, the SW can be launched by means of simple feeds in the substrate.

Unfortunately, typical designs with 30 dBi gain present a bandwidth around 5%, which is not sufficient neither for simultaneously receiving/transmitting in the up-link/down-link frequencies of a given Deep Space Network (DSN) band, nor for covering different DSN bands. We will thus present two innovative solutions to design MTS antennas with dual-band operation, while preserving a good polarization purity and the desired beam shape on both frequency bands. Although other polarizations and patterns can be obtained, we will consider circularly polarized (CP) broadside pencil beams, as in DSN requirements. In the first approach, we have studied a circular aperture, fed at its center by a cylindrical SW launcher. The modulation of the inductance tensor is defined using a set of parameters, which must be selected in order to obtain the desired radiation patterns at the frequencies of interest. Several combinations of the available parameters have been considered in a parametric analysis, and the frequency response of the structure analyzed. Based on this parametric study, one can select the optimum values in the bands of interest. In the second approach, the inductance tensor is defined as a superposition of individual modulations, which correspond to those required to obtain CP pencil beams at two different frequencies. This can be done using either a port or one feed point per frequency. The main advantage of the latter approach is the possibility of having a self-diplexed antenna, which eliminates the need of a wideband feed. A set of closed-form expressions have been derived for inductance tensor in this second case. Both techniques have been first analyzed using a MoM formulation for continuous impedance boundary conditions (D. González-Ovejero and S. Maci, IEEE Trans. Antennas Propag., 2015, 63.9: 3982-3993), and then validated with a Fast Multipole Method (FMM) full-wave code. The inductance tensor patterns obtained with both approaches, and their corresponding frequency responses and radiation patterns will be discussed at the conference.