Compact Expressions for Efficiency and Bandwidth of Modulated Metasurface Antennas

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Modulated metasurface (MTS) antennas are a class of leaky wave (LW) antennas constituted by a grounded thin dielectric layer, loaded by a quasi-periodic, tight disposition of small metallic patches. These patches form the MTS and impose the impedance boundary conditions (BCs) seen by a SW excited on the loaded grounded slab. The BCs are modulated in a sinusoidal manner around an average value and the interaction with them transforms the SW into a LW. The radiative field is controlled by the BCs and thus, through the MTS, it is possible to control the radiation pattern (shaped, contoured or directive beams) and the field polarization (linear or circular).

Modulated metasurface antennas have been shown to be a promising alternative to reflector antennas, particularly suited for space applications (G. Minatti *et al.*, IEEE Trans Antennas Propagat., 63(4), 1288-1300, April 2015.). However, due to their relatively recent introduction, some aspects of their potential performances have still to be fully clarified. In this work, we have investigated efficiency and bandwidth of MTS antennas from a theoretical point of view. Concerning the efficiency, several contributions have been identified and quantified. The feed efficiency is the power delivered by the feed in SW over the total input power. The ohmic efficiency takes into account the antenna losses. The tapering efficiency quantifies the deviation with respect to a uniform illumination. The conversion efficiency quantifies the amount of SW power converted into LW power. The product of all of them gives the overall antenna efficiency.

For what concerns the bandwidth, we have found that, for an appropriate choice of the modulation depth, the relative bandwidth is inversely proportional to the antenna radius in terms of a wavelength. This inverse proportionality is ruled by a coefficient which is directly proportional to the group-velocity at the central frequency of the SW supported by the average-impedance. It is seen therefore that the product bandwidth-gain is linearly proportional by means of the same coefficient to the antenna radius in wavelengths.

The objective of this contribution is that of facing efficiency and bandwidth of MTS antennas through an analytical approach. At the conference, we will present compact expressions for estimating bandwidth and efficiency and we will provide useful indications for the design of MTS antennas.