On the Use of Bianisotropic Huygens' Metasurfaces to Build Leaky-Wave Antennas

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ABSTRACT

Huygens' metasurfaces are considered a powerful tool to achieve anomalous electromagnetic field transformations. They consist of an artificial surface built of pairs of collocated electric and magnetic dipoles that force the boundary conditions for the desired transformation to be fulfilled [1]. Despite their possibilities, the achievable transformations must fulfil some conditions. In [2] it was shown that Huygens' metasurfaces with passive and lossless particles can achieve an arbitrary field transformation provided that the power is conserved at each point of the metasurface and there is wave impedance matching. However, it was shown in [3], that by introducing bianisotropy of the omega-type, the matching condition can be suppressed, which allows the control of both the transmission and reflection coefficients on the metasurface.

Leaky-wave antennas are receiving considerable interest lately due to their simple feeding and scanning capabilities. They are open guiding structures along which a propagated wave is gradually leaking power in the form of radiation [4]. However, the link between the propagation constant (determined by the structure geometry) and the radiation characteristics usually imposes some limitations in the arbitrary control of the radiation pattern.

The previously mentioned capability of bianisotropic Huygens' metasurfaces to control both the transmission and reflection coefficients on the interface of a field transformation can be exploited to build leaky-wave antennas. This includes facility in radiation at broadside since it becomes possible to excite only a single radiating harmonic. The authors used this concept to transform an arbitrary leaky mode, traveling in a parallel-plate waveguide, into a radiated mode with powerful control of the radiation pattern [5]. In this communication, we review the concept and theoretical derivation and provide several design examples of how the combination of leaky-wave antennas with bianisotropic Huygens' metasurfaces can be a powerful tool to control the parameters of the leaky-mode and, consequently, the characteristics of the radiation (pointing direction and leakage rate) in this kind of antennas. Additionally, experimental results will be provided and analysed. In this way, the whole process, from the concept and theoretical derivation to the challenging physical implementation and experimental verification will be discussed.

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