Transformational Electromagnetics for Designing Tensor-Impedance Surfaces for Surface-Wave Waveguides

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Surface-wave waveguides (SWGs) are structures that constrain surface waves (SWs) to propagate along a confined path. SWGs can be used for various applications related to antennas. An SWG can be used to focus SWs to a point, bend them around corners, or guide them around objects that would scatter radiation into free space. SWGs are created with Tensor Artificial Impedance Surfaces (TAIS). In previous work (D.J. Gregoire and A.V. Kabakian, IEEE Ant. and Wireless Prop. Letters, 10, 1512-1515, 2011), we showed how a TAIS can be designed to bend a SW around a curve without distortion by using the SW differential velocity method (DVM) to tailor the tensor impedance such that it coherently rotates the SW Poynting vector across the SW phase front. DVM dictates that the SW locally propagates along the TAIS principle axis with lower impedance, and the impedance is tailored such that the SW velocity across the phase front is proportional to the path's radius of curvature.

In this paper, we derive a surface-wave version of transformational electromagnetics (TRM), and show how it is equivalent to DVM. TRM and DVM are compared by using them to produce the impedance maps for bending, focusing, and object–avoidance applications, and measurements of the corresponding TAIS SWGs are presented. We then present measurements of SWGs fabricated for those purposes. In particular, we highlight the design, simulation and measurement of an SWG integrated into a forward-looking artificial-impedance-surface antenna (AISA) that mitigates blockage effects due to an obstacle on the AISA surface. The AISA's feed point is behind the obstacle, and the SWG guides surface waves around the obstacle in order to place the antenna aperture where it is not blocked. The radiation patterns with and without the obstacle in place are compared.