Advances in Tunable Impedance Surfaces for Leaky Wave Beam Steering and Adaptive Antennas

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Abstract:

Recently, antenna designers have seen an evolution from conventional metal ground planes into engineered ground planes, whose surface wave properties and diffraction characteristics can be tailored to fit a variety of applications. This began with the corrugated structures, now often known as soft and hard surfaces, [1] and eventually progressed into two-dimensional textured surfaces. [2] These materials allow one to define the sheet impedance and other properties of a metal surface using effective lumped circuit parameters.

Several applications have emerged for these new materials, such as low-profile antennas that can lie directly adjacent to a metal surface. While various thin antennas have existed for years, these textured ground planes expand the antenna designer's toolbox, resulting in new concepts such as horizontally polarized, low-angle directive antennas. [3] Many of these can be understood as a manipulation of surface wave modes.

Now, with the development of tunable surfaces, new kinds of active and adaptive antennas are possible. For example, steerable reflectors have been built using mechanically [4] or electrically tunable surfaces, which offer a low-cost alternative to conventional phased arrays, although they typically require illumination by a separate feed.

Recently, steerable leaky wave antennas have been built using these same surfaces, which allow the feed to be conformal with the steerable surface. (See figure 1.) These antennas can steer over a broad range of angles, (See figure 2.) using an entirely planar design, and a single integrated feed. This talk will describe recent advances in tunable surfaces, and will introduce new concepts for steerable leaky wave antennas based on them.

[1] P.-S. Kildal, “Artificially Soft and Hard Surfaces in Electromagnetics”, IEEE Trans. Ant. Prop. vol. 38, pp. 1537-1544, 1990

[2] D. Sievenpiper, “High-Impedance Electromagnetic Surfaces”, Ph.D. dissertation, UCLA, 1999

[3] J. J. Lee, R. J. Broas, S. Livingston, D. Sievenpiper, "Flush-Mounted Antennas on Hi-Z Ground Planes", IEEE APS Symp. Dig. vol. 3, pp. 764-767, 2002

[4] D. Sievenpiper, J. Schaffner, R. Loo, G. Tangonan, S. Ontiveros, R. Harold, "A Tunable Impedance Surface Performing as a Reconfigurable Beam Steering Reflector", IEEE Trans. Ant. Prop. vol. 50, pp. 384-390, 2002

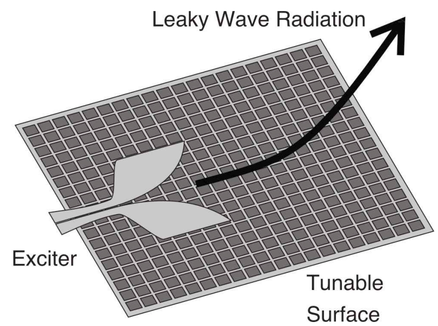

Figure 1. A steerable leaky wave antenna can be built using a tunable impedance surface. An exciter launches a leaky wave, which then radiates at an angle determined by phase matching on the surface.

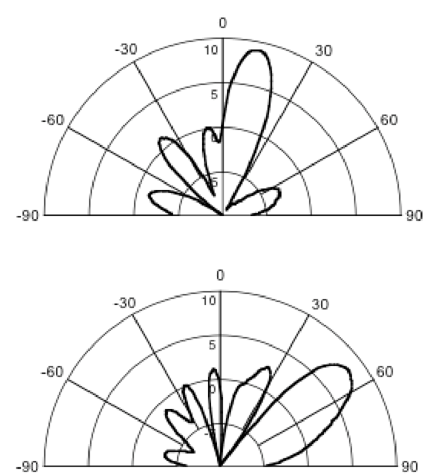

Figure 2. An example of beam steering using a tunable impedance surface The beam can be steered in the elevation plane by varying the impedance of the surface, and shifting the surface wave band structure. Near-broadside and near-endfire patterns are shown.