RESONANCE CONE RADIATION FROM A PLANAR, ANISOTROPIC METAMATERIAL

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The metamaterial under study is based on a square-celled, planar, wire-grid network that is series-loaded with capacitors in one direction and inductors in the orthogonal direction (or equivalently loaded with distributed elements). Further, this two-dimensional grid is positioned over a horizontal ground plane and parallel to it, and an inductor-loaded vertical wire is dropped from each grid-wire intersection to ground. For the computational simulation results to be discussed here, the overall configuration is square-shaped and excited by a voltage source located at one corner and inserted in a wire connected between the grid and ground. At this conference last year (2002 URSI Digest p. 45), and for a configuration similar to the present one but lacking the grid-to-ground inductive branches, it was found that the near fields were concentrated along radial lines called resonance cones extending outward from the corner source. For the present configuration, the resonance-cone high-field regions are still in evidence at similar angles. The key difference now is that the vertical inductive branches carry enough current to contibute significantly to the radiation fields, especially the vertically polarized ones that propagate in near-horizontal directions.

The corner-to-corner diagonal resonance cone provides useful examples of radiation patterns. The designs tried so far tend to be low-profile, with heights on the order of a twentieth of a wavelength. For a particular choice of parameters, the near-field phase is nearly constant along the resonance cone, producing a radiation pattern horizontal main lobe that is near-broadside with respect to the cone direction. A further benefit arises from the fact that the resonance cone near fields exhibit a rapid phase shift horizontally across the cone direction. This phase shift is sufficient to produce a near-null in the horizontal-plane radiation pattern, to one side of the cone, thus making the horizontal broadside radiation unidirectional. Still further, the radiated-field source distribution tends to be concentrated near the driven end of the array, a common problem with other types of leaky-wave antennas. Our solution is to employ graduated-height tapering of the array, which has so far proved to be satisfactory.

For other parameters, the near-field equiphase contours approximate straight lines cutting across the resonance cones at particular angles in the horizontal plane, such that the normals to these lines in the vicinity of the cones correspond to the directions of the radiation maxima. This translates into an opportunity for electronic beam steering.