Matching Bandwidth Limits for Linearly Polarized Scanning Arrays above a Ground Plane

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Wideband phased arrays have become critical components for a new generation of radar and wireless communications systems. The authors have previously shown that arrays that are conformally installed on a ground plane will have reduced bandwidth due to the ground plane's reactance. Fundamental limits for such low profile arrays above a conducting ground plane were derived [Doane et.al., *IET Electronics Letters*, 2012], yielding simple expressions for the maximum realizable bandwidth under either TE (H-plane scanning) or TM (E-plane scanning) excitation. However, a general bandwidth limit for arbitrary polarization has yet to be presented. In this paper, we present improved bandwidth limits for linearly polarized arrays scanned to any angle, including the inter-cardinal planes where both TE and TM modes are simultaneously excited. For the latter, TE-TM coupling is accounted for.

To derive the bandwidth limits for an arbitrarily polarized array, we proceeded to represent it by a lossless 3-port network. Specifically, one of the ports represents the array feed and the other two ports represent the individual TE and TM Floquet modes. The response of each Floquet mode port is constrained by the previously derived limits, and the corresponding bandwidth limit at the array port is then determined by enforcing the unitary properties of the 3-port scattering matrix and the analyticity of the 3-port admittance matrix. Previous techniques for solving such 3-port matching problems were tedious and did not yield a general closed-form limit for arbitrary excitation of the ports. In this paper we present a novel technique for solving the 3-port matching problem under arbitrary excitation, leading to a simple closed-form bandwidth limit for conformally mounted periodic arrays. The developed limits yield a tight bound on the bandwidth of linearly polarized arrays above a ground plane. They also yield an upper (though not necessarily tight) bound for arrays of arbitrary polarization (including elliptical and circular). There is an implied assumption that the polarization does not significantly change over frequency.

Among the conclusions from the derived bandwidth limits, we note that: (1) The bandwidth of an array with a single feed port and passive combiner network is maximized when the TE and TM modes are excited in phase, producing linear polarization. This differs significantly from the behavior of electrically small antennas, which obtain maximum bandwidth when the TE and TM modes are fed in quadrature. (2) The bandwidth limit for linearly polarized arrays increases monotonically from the lower TE limit to the larger TM limit as the array is scanned through the inter-cardinal planes. That is, the bandwidth limit for a linearly polarized array scanned to any given angle from normal is bounded above by the TM (E-plane) limit and below by the TE (H-plane) limit for that scan angle