PHASED ARRAYS OF PRINTED ANTENNAS

David M. Pozar
Department of Electrical and Computer Engineering
University of Massachusetts
Amherst, MA 01003

GaAs $\epsilon_r = 12.8$

I. Introduction

There is a growing interest in monolithic phased arrays, where the antenna elements are printed on the same substrate with active devices, such as phase shifters, mixers, or amplifiers. This concept has the potential of providing the long-awaited goal of a low-cost phased array antenna.

Such an antenna would probably use a substrate such as Alumina, Silicon, or Gallium Arsenide in order to facilitate the fabrication of active devices, and so would have a relatively large dielectric constant in the range of 10 to 13. In addition, such phased arrays may be employed in the millimeter wave region where the substrate would be relatively thick electrically. The combination of a high dielectric constant and a thick substrate constitutes a serious problem in that surface waves are excited which lead to scan blindness (a condition where, for a particular scan angle, no real power can be received or transmitted by the array). Also, the active impedance variation with scan angle is significantly affected by the substrate parameters.

II. Content of Paper

This paper will summarize a number of recent results [1], [2], [3], [4] related to phased arrays of printed antennas. Infinite arrays of printed dipoles and microstrip patches will be discussed, as will finite arrays of printed dipoles.

The solutions to each of the above configurations are very similar. Briefly, a moment method solution for the unknown electric surface current density on the dipole or patch is formulated for a single printed element, using piecewise-sinusoidal functions as expansion modes. The substrate is rigorously accounted for by using the Green's function for the substrate expressed in terms of a double Sommerfeld-type integral. This solution for a single element is then converted to the solution for an infinite array of such elements by using a theorem involving the Poisson Sum formula. The double Sommerfeld-type integral is then converted to a double infinite summation in this procedure. The method can also be viewed as a discretized spectral transform domain solution. Finite arrays can also be treated.

This solution provides the active input impedance for any scan angle and scan plane. Grating lobes and surface wave effects are included in the formulation. The paper will present examples of the active reflection coefficient for various geometries and parameters such as interelement spacing, substrate thickness, substrate permittivity, and array size. The avoidance of grating lobes will be discussed, and the scan blindness phenomenom will be shown and explained in terms of a forced surface wave response. "Surface wave circles" on a modified grating lobe diagram will be introduced as an aid in predicting and explaining scan blindness.

III. Examples

Figures 1 and 2 show some typical results for phased arrays of printed dipoles. The substrate is $0.06\lambda_o$ thick, and has a dielectric constant of 12.8. The dipole length is $0.156\lambda_o$, and the width is $0.01\lambda_o$. The inter-element spacing is $0.5\lambda_o$ in both planes.

Figure 1 shows the reflection coefficient magnitude vs. scan angle for E and H-plane scan, for a 7x7 array and an infinite array. Note the scan blindness angle at about 45°. Figure 2 shows the E and H-plane active element patterns for various sizes of the same array. Observe that the E-plane pattern shows a deep null at the blindness angle.

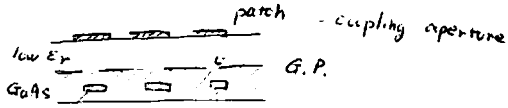
References:

[1] D. M. Pozar and D. H. Schaubert, "Scan Blindness in Infinite Phased Arrays of Printed Dipoles", IEEE Trans. Antennas and Prop., Vol. AP-32, pp. 602-610, June 1984.

[2] D. M. Pozar and D. H. Schaubert, "Analysis of an Infinite Array of Rectangular Microstrip Patches with Idealized Probe Feeds", IEEE Trans. Antennas and Prop., Vol. AP-32, pp. 1101-1107, October 1984.

[3] D. M. Pozar, "General Relations for a Phased Array of Printed Antennas Derived from Infinite Current Sheets", IEEE Trans. Antennas and Prop., to appear, May 1985.

[4] D. M. Pozar, "Analysis of Finite Phased Arrays of Printed Dipoles", IEEE Trans. Antennas and Prop., submitted for publication.



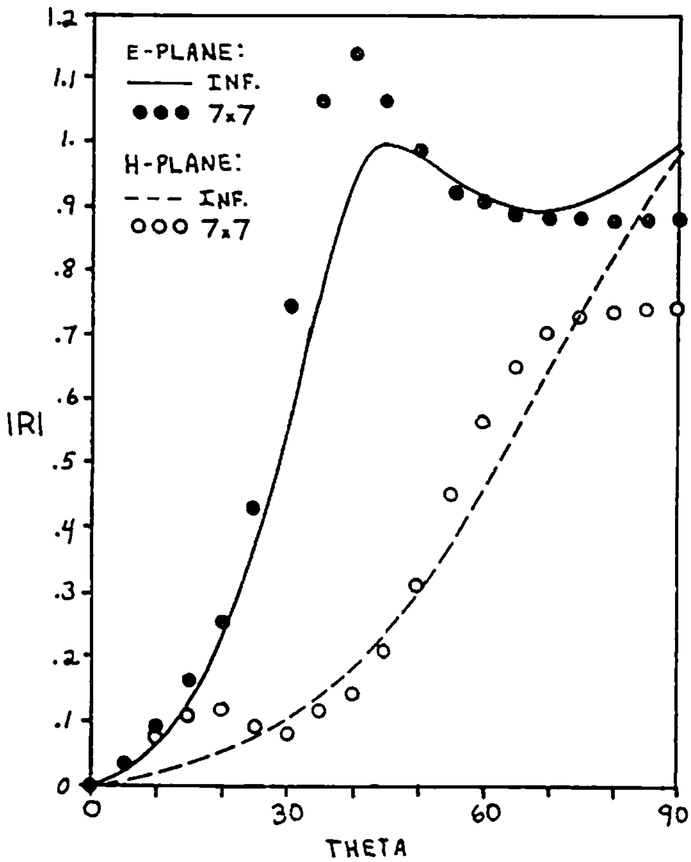


Figure 1. Reflection coefficient magnitude for phased arrays of printed dipoles.

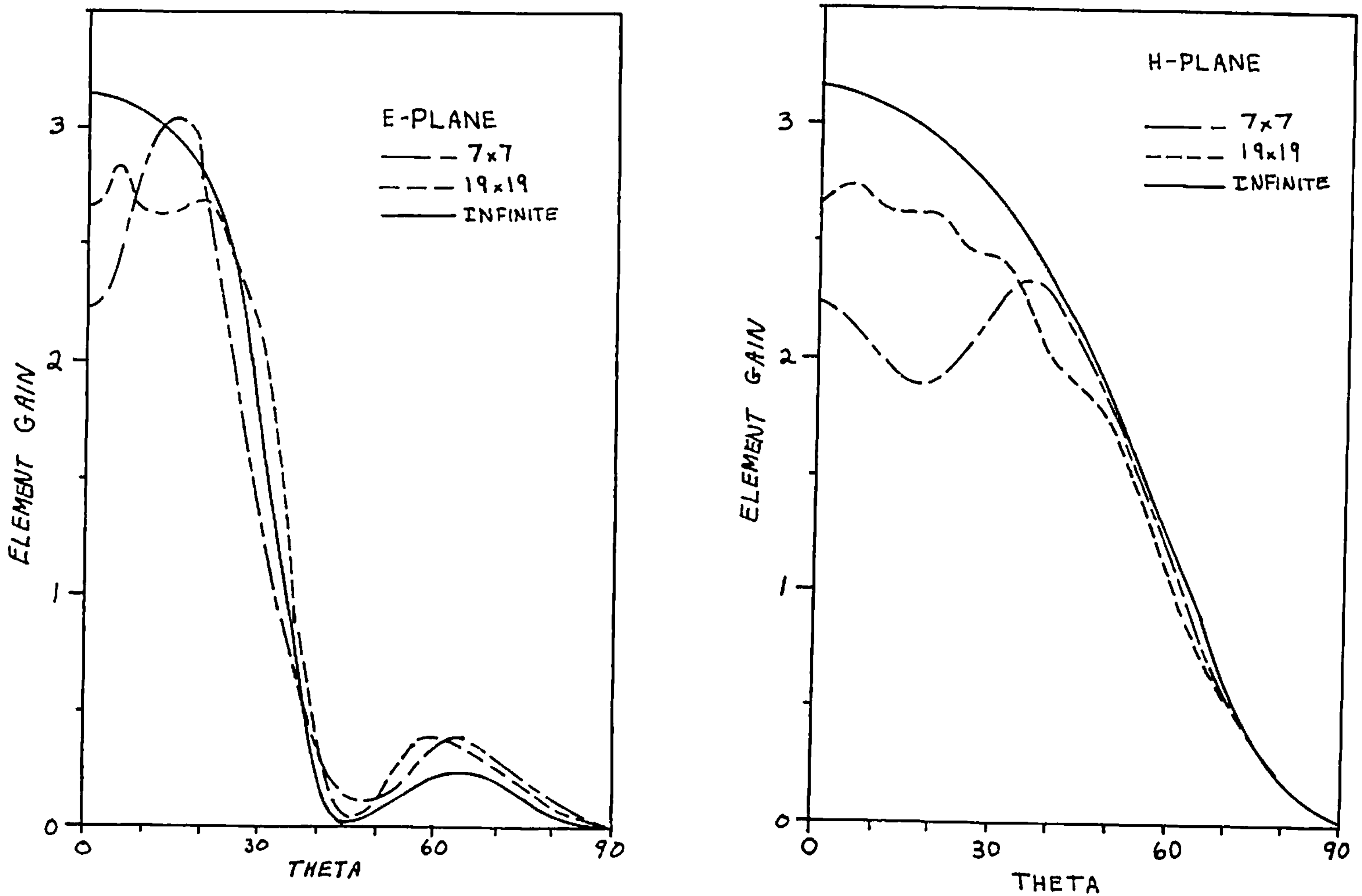


Figure 2. E and H-plane active element gain patterns for phased arrays of printed dipoles.