Mutual Coupling Compensation in Digital Beamforming Arrays of Parallel-Plate-Guide-Fed Slits on a Ground Plane

Boris Tomasic*(1), Victor Zaharov(2), and Carl Pfeiffer(3)
(1) Air Force Research Laboratory, Sensors Directorate,
Wright-Patterson AFB OH 45433, boris.tomasic@us.af.mil
(2) Polytechnic University of Puerto Rico, San Juan, Puerto Rico 00918, vzaharov@pupr.edu
(3) Defense Engineering Co., 4027 Col Glenn Hwy, Beavercreek, OH 45431, carl.pfeiffer.2.ctr@us.af.mil

In analog Electronically Scanned Arrays (ESA/AESA) as well as in Digital Beamforming (DBF) arrays the performance is degraded by mutual coupling effects, causing different embedded element patterns, and consequently the array edge effects and element/scan -dependent active reflection coefficients, see Fig.1. Thus, mutual coupling compensation is the key feature in practical DBF arrays where a small investment in hardware and software can result in substantial improvement in performance such as multiple simultaneous beams, adaptive pattern nulling for suppression of interference and jammers, element pattern correction, ultra-low sidelobes and self-calibration. There has been number of papers published on compensation of mutual coupling in DBF ESAs (1, Steyskal and Herd, IEEE Trans. on AP, 1990). However, the proposed techniques have not been practically implemented up to date in any major systems. One of the main reasons could be that most of the papers demonstrated their techniques based on combination between theoretical and measured data that resulted in improved patterns but still with significant errors of the unknown origin.

In this paper, we compensated mutual coupling effects with technique similar in (1) where embedded element patterns were determined from isolated element pattern perturbed by the array elements via scattering coefficients. In contrast to (1), the present study directly calculates scattering matrix (which can be also measured experimentally) instead of calculating them from measured embedded element patterns. As in (1), the compensation for the mutual coupling can be accomplished by simply multiplying the received signals $\mathbf{v}$ by the inverse coupling matrix $\mathbf{C}^{-1}$, i.e., $\mathbf{v}^{\mathbf{d}} \simeq \mathbf{C}^{-1}\mathbf{v}$ where $\mathbf{v}^{\mathbf{d}}$ represents the unperturbed desired signals. The mutual coupling matrix is directly related with the array scattering matrix by $\mathbf{C}=\mathbf{I}+\mathbf{S}$.

We demonstrated the method on a simple 1D array of Parallel-Plate-Guide-Fed Slits on a Ground Plane. We selected this geometry because it can be analyzed analytically, and all errors due to approximations in the method, as well as numerical errors can be accurately accounted for. The analytical results are also compared with simulated results using COMSOL. Our matrix for success is to compare the patterns of an array with isolated elements, which means with no mutual coupling ($\mathbf{S}$=0) with an array of elements with (actual) embedded element patterns - as seen in Fig. 2, the match is perfect.

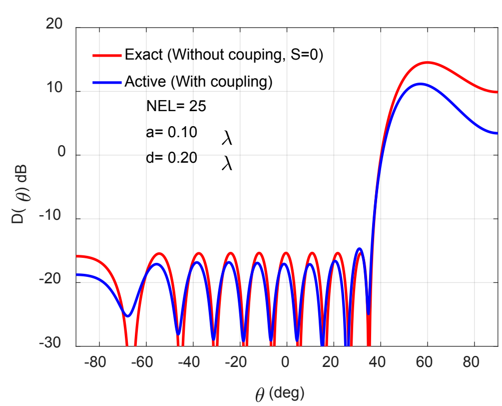

Fig. 1 -30dB Chebyshev pattern with and without coupling, $\theta_0=60^0$

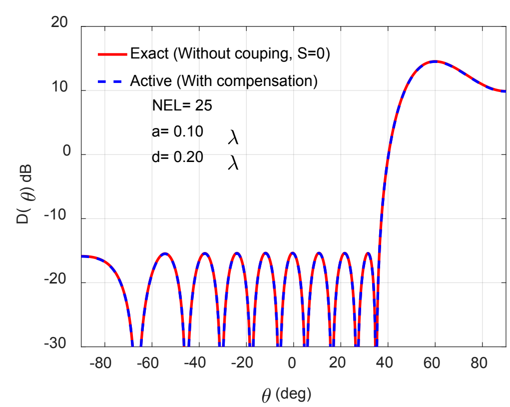

Fig 2. -30dB Chebyshev pattern with coupling, and active array with compensated coupling, $\theta_0=60^0$