Convex Optimization of Endfire Array Antenna Feeding

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A large finite endfire array antenna is a challenging computational problem. The excitation needs to be properly defined in order to launch the desired mode, and port matching across the array becomes more difficult as the radiation occurs across the array, potentially causing large active reflection coefficients in the elements. An appropriate measure for the matching of a multiport system is the Total Active Reflection Coefficient (TARC) (M. Mantegi and Y. Rahmat-Samii, IEEE Trans. Antennas Propag., 53, 466-474, 2005): $\sqrt{(\sum_n |b_n|^2)/(\sum_n |a_n|^2)}$. Here, b_n and a_n represent the backward- and forward-propagating wave in port n, respectively. Evidently, the TARC represents the overall matching under a *single* frequency excitation. The classic endfire feeding approach would be the Hansen-Woodyard progressive phase shift condition (W. W. Hansen and J. R. Woodyard, Proc. IRE, 26, 333-345, 1938).

Here, the feeding problem is instead formulated as a convex optimization problem as follows, using the input waves $\{a_n\}_{n=1}^N$ as degrees of freedom:

$$\begin{array}{ll} \text{minimize} & \sum_{n=1}^N |b_n|^2 \\ \text{subject to} & F(0) = 1, \quad \max\limits_{|\phi|>\phi_0} |F(\phi)| \le F_0. \end{array} \tag{1}$$

$F(\phi)$ is the far field amplitude in azimuth angle ϕ, F_0 is a specified side lobe level, and the main lobe is to be contained within $\phi \in [-\phi_0, \phi_0]$. The optimization routine is run on a 200×12 dipole array, but can be employed on more complex antenna geometries by utilizing a hybrid Method of Moments code developed for the purpose of treating very large antenna arrays with antenna elements of complex geometry (J. Helander and D. Sjöberg, EMTS Conf., 2016). The routine is run at a single frequency f_0, and a smooth dependence on frequency for the feeding currents is introduced as a linear phase shift with respect to f_0: $a_n(f) = a_n(f_0)\mathrm{e}^{-\mathrm{j}(k-k_0)n_x d_x}$. This eliminates the randomness in the input wave phases and amplitudes as functions of frequency, which would be introduced if the optimization scheme would be run independently at each frequency. The TARC for feeding amplitudes $a_n(f)$ defined as above, compared to the results of frequency independent optimization and the Hansen-Woodyard excitation, are shown in Fig. 1 together with a corresponding radiation pattern. With currents being easier to realize as functions of frequency and a non-significant change in the radiation pattern across the frequency band, the frequency dependent solution is preferable despite a slightly reduced bandwidth.

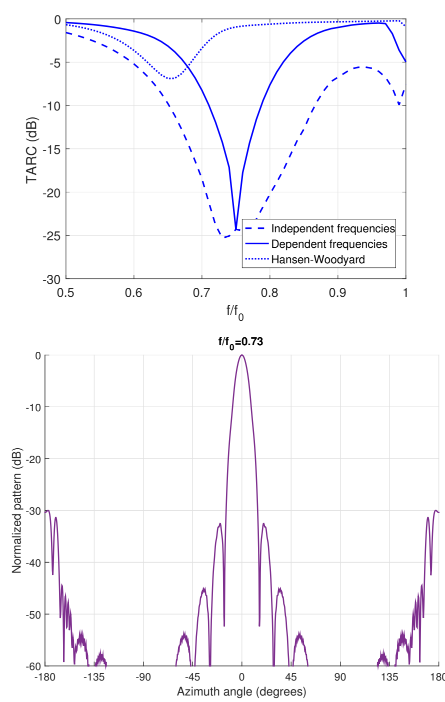

Figure 1: TARC and azimuth radiation pattern at $f = 0.73 f_0$.