Semidefinite Relaxation-Based Optimization of Reactively Loaded Dipole Antenna Arrays

Analysis, Design and Verification

Student

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Introduction: Reactive loading is a well-known technique for antenna arrays to manipulate the radiation pattern of an antenna array, for example to achieve maximum gain in a specific direction. For this purpose, every antenna in the array is loaded by a specific reactance, whose value is usually found by a dedicated optimization algorithm. In this project, a semidefinite relaxation-based (SDR) optimization framework, originally developed for wireless power transfer in the near-field, is used to optimize the gain of an array antenna in the far-field, while simultaneously maintain sufficient impedance matching.

Approach: A multi-purpose PCB is developed to verify the practical applicability of the SDR-based optimization framework on five- and seven-element half-wave dipole array configurations, as shown in Fig. 1. Special attention is devoted to preserving overall symmetry as much as possible; asymmetry causes significant deviations from the predictions. In addition, sensitivity analysis on gain and impedance matching sheds light on the tolerances of the discrete elements, as visualized in Fig. 2. According to these results, the array antennas are then realized and measured.

Result: The SDR-based optimization leads to practically realizable reactively loaded antenna arrays whose gains are indeed maximized as desired. The sensitivity analysis shows that strict impedance matching constraints are generally difficult to satisfy in practice and indicates which component tolerances are most significant. The gain in the main direction is not as sensitive to tolerances, as shown in Fig. 3, where the simulations and measurements agree to a deviation of less than 1dB. All these results will be presented at the 2021 Antenna & Propagation International Symposium (AP-S) in Singapore.

Figure 1: Multi-purpose PCB, configured as five-element half-wave dipole array with equal element spacing.
Own presentment

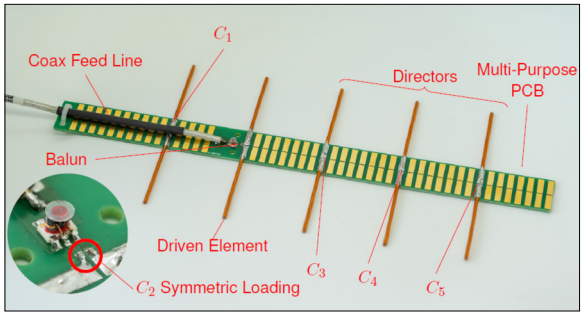


Figure 2: Sensitivity analysis for the two most sensitive loads in terms of impedance matching (a) and maximum gain (b).
Own presentment

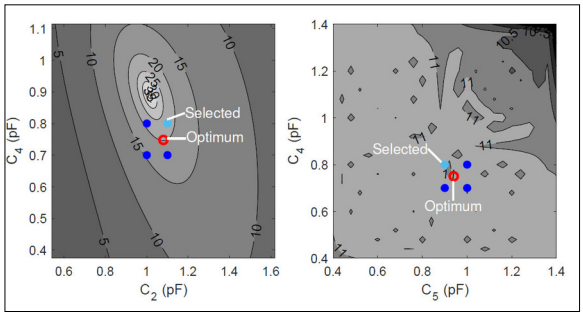
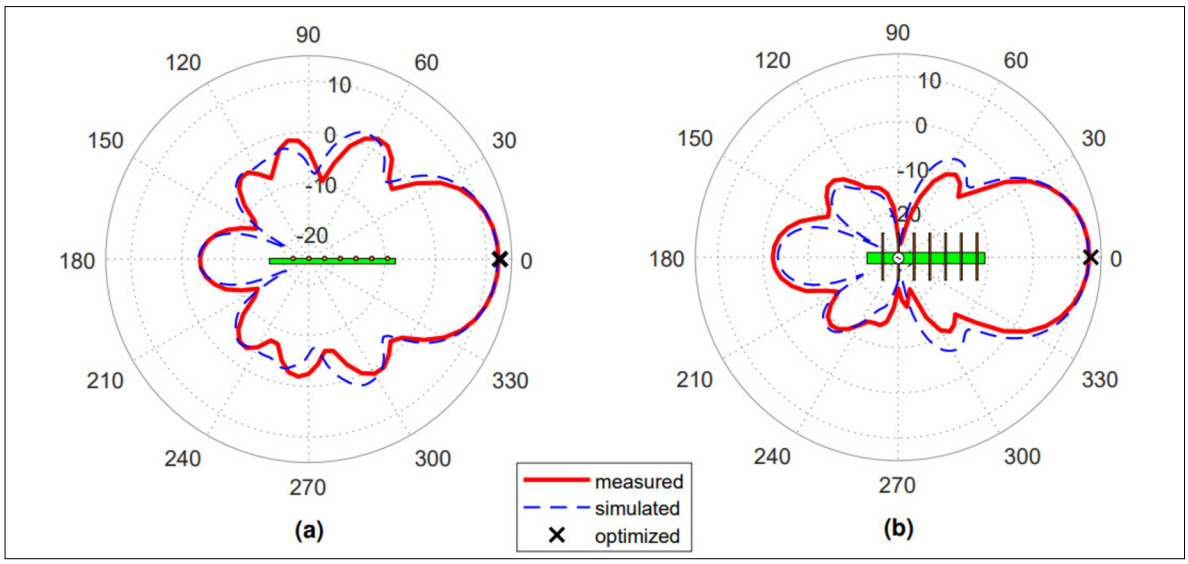


Figure 3: Measured and simulated radiation patterns for the 7-element array. Symmetry is essential for good agreement.
Own presentment



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Subject Area
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