Optimal antenna currents using convex optimization

Gustafsson, Mats

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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Mats Gustafsson
Dept. Electrical and Information Technology Lund University, Box 118, SE-221 00 Lund, Sweden,
e-mail: mats.gustafsson@eit.lth.se

Design of small antennas is challenging because of the high Q-factor (low bandwidth), low efficiency, and often low radiation resistance [1]. The fundamental trade-off between performance and size of the design volume is expressed by physical bounds. Chu computed bounds on the Q-factor, Q, from the stored and radiated energies outside a sphere that circumscribes the antenna, see [1] for an overview. The bounds were generalized to arbitrary shaped antennas in [2, 3].

In [4], optimal currents and physical bounds on D/Q are formulated as an optimization problem using the expressions for the stored energies presented by Vandenbosch [5]. Here, convex optimization [6] is used to determine optimal current distributions on arbitrary shaped antennas for minimum Q, maximal G/Q, superdirective antennas, and antennas with prescribed radiated fields [4, 7]. This generalizes the physical bounds in [1, 2, 3] in many ways. We also show how losses and antennas embedded in perfectly electric conducting structures can be included in the bounds. The new results are for arbitrary shaped structures but restricted to antenna structures composed of metallic or dielectric materials. Moreover, we restrict the size of the antenna structure to approximately half a wavelength to obtain positive semidefinite energy expressions, see [4]. This restricts the presented results to $Q \gg 1$ that coincides with the size restriction on the antennas considered here. Convex optimization is used in many areas [6] and it has *e.g.*, been used extensively to determine array patterns. The formulation as a convex optimization problem is advantageous as it has a well-developed theory [6] and there are efficient solvers. The theoretical results are illustrated with numerical simulations for antennas confined to planar rectangles.

References

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