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Q-factor Bounds for Microstrip Patch Antennas

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Summary

This work computes lower Q-factor bounds of microstrip patch antennas using current optimization. These bounds consider all possible geometries in a predefined rectangular design region. Further, the bounds are shown to be near the performance of realistic patch designs and are therefore of practical interest.

1 Abstract

Microstrip patch antennas are often limited by their relative narrow bandwidth. Here lower Q-factor bounds for microstrip patch antennas [1], orders of magnitude tighter than the Chu limit [2] are presented. These bounds provide achievable bandwidth benchmarks [3] and a guide to assess required design parameters. The minimum Q-factor for a rectangular patch design region is determined using current optimization [4, 5, 6, 7, 8].

To obtain lower Q-factor bounds an infinite dielectric and ground plane are assumed, where the dielectric has given relative permittivity ε_r and thickness h. On top of the dielectric substrate is a rectangular design region with dimensions ℓ_x and ℓ_y. The Q-factor can then be computed from the currents on the patch design region alone since using Sommerfeld integrals the currents on the ground plane are implicitly considered in the Green's function [9]. This formulation relies on the method of moments (MoM) [10].

The lower Q-factor bounds are computed for a patch design region with dimensions $\ell_\mathrm{y} = 0.77\ell_\mathrm{x}$ and dielectric thickness $h = 0.05\ell_\mathrm{x}$. The bounds are computed over a range of electrical sizes ℓ_x/λ where λ is the free space wavelength. These results are shown in Fig. 1 for three dielectric relative permittivities. They shown that realistic antennas have Q-factors near the bounds. Further, the presented bounds are orders of magnitude tighter than the Chu limit due to considering a planar design region as opposed to a spherical one. A detained analysis of these results are found in [3]

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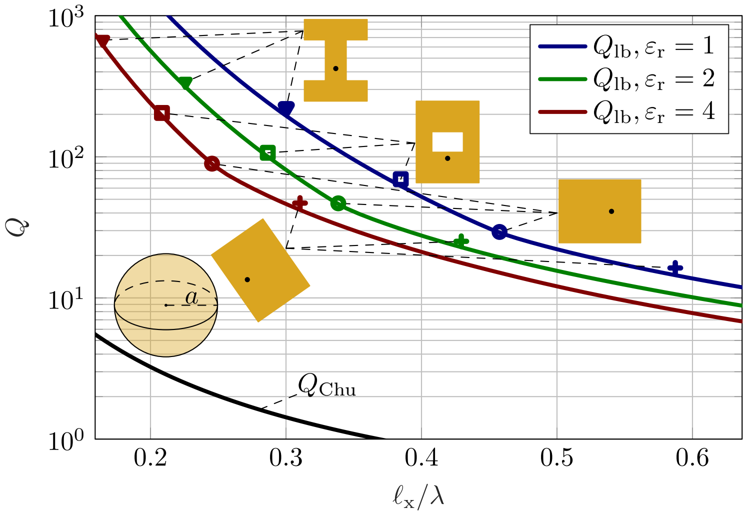

Figure 1. Demonstration of the tightness of lower Q-factor bounds for a rectangular design region with aspect ratio $\ell_y = 0.77\ell_x$, substrate thickness $h = 0.05\ell_x$ and relative permittivity $\varepsilon_r \in \{1,2,4\}$ computed using current optimization. FEKO [11] simulation results for self-resonant antennas with Q-factors [12] indicated with markers. To place the new bounds into perspective, the Chu limit ($Q_{\rm Chu}$) [2] is included.

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