Are prefractal monopoles optimum miniature antennas?

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Radiation efficiency and impedance bandwidth are reduced with the electrical size of the antennas. This makes small antennas inefficient by nature (low radiation resistances, high ohmic losses, high currents in the conductor, high energy stored in the near-field of the antenna). The inefficient performance of small antennas is summarized by the high values of the quality factor (Q), already predicted by the fundamental limit stated by Chu and reexamined by McLean. This limit starts from the hypothesis that an infinitesimally small antenna radiates only a TE_{01} or TM_{01} spherical mode and that depends on the electric size of the antenna k_0a, being k_0 the wave number at resonance, and a the radius of the smallest sphere that encloses the antenna (and its image in the case of monopoles). However, real antennas do radiate more reactive modes contributing to higher Q values.

Lowering the Q of an electrically small antenna ($k_0a<1$) is only possible by a proper utilization of the volume that surrounds it in establishing a TE_{01} or TM_{01} mode, or by reducing the efficiency of the antenna ([R.C. Hansen, Proc. IEEE, 69, 170-182, Feb. 1981]). Altshuler ([E.E. Altshuler, TAP, 44, (6), 787 –791, June 1996]) used Genetic Algorithm optimization to search for 3D self-resonant wire antennas "that best utilize the volume within which the antenna is confined". Constraints posed in the analyzed structures were the number of wire segments connected in series contained in a cube of specified volume. Measurements assessed with simulations carried out with NEC. The optimization lied in the minimization of a figure of merit combining both resonance frequency and bandwidth of operation. Unfortunately, the absence of information about radiation efficiencies and ohmic losses unables any comparison on the efficiency of the technique for the design of small antennas but stated the potential of the method.

Being the electric size (k_0a) of the antenna who limits its performance in terms of Q, the purpose of this work is applying Genetic Algorithms optimization for the design of small bidimensional (inscribed in a plane) wire monopoles. A multiobjective optimization is used to optimize both quality factor and radiation efficiency at resonance for an specified electric size of the antenna. GA-optimized designs will be compared with prefractal structures showing that the same degree of miniaturization can be achieved with better performances. Preliminary results have been obtained (and also will be shown) from the analysis of Koch monopoles.

Conclusions from bidimensional wire monopoles can be extended to 3D antennas. Bidimensional wire monopoles are our objective antennas because they are easily manufactured using conventional techniques for the fabrication of printed circuit boards, and they do not need baluns to balance currents. Radiation efficiencies and quality factors are measured using the Wheeler cap method.