Nelder Mead Simplex Algorithm To Optimize Geometry For Maximum Objective Function Value

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Abstract

Design of the electromagnetic system requires a procedure where certain parameters need to be maximized under constraints placed on its dimensions. Optimization routines that can maximize the function value under given constraints are required. Design of such systems coupled with the optimization routine can be achieved in COMSOL optimization study using the Nelder Mead (NM) simplex algorithm. NM is a derivative-free optimization routine that proceeds toward improved objective function value by iteratively replacing the worst point in the control variable space and is suitable for the electromagnetic system design. In COMSOL optimization study, NM is used to maximize the coupling coefficient 'k' between two electrically isolated coils and geometry dimensions, that can alter this function value, are used as control variables. A 2D axisymmetric frequency domain problem is set up where two coaxial symmetrical circular inductors are designed to get maximum value of k. A design constraint is placed on the maximum possible dimensions and limits within which inductor's core width and core & coil radial distance from the central axis can vary. NM simplex maximization study in COMSOL is found to reach a solution in iterations successively replacing worst solutions in the design space and eventually returning geometry parameters that lead to highest possible value of k. The obtained solution also shows the mutual flux between two coils is maximum when both coil and core are of the maximum possible diameter. This is true in theory as the maximum possible diameter of planar circular coils reduces the leakage flux which leads to the higher value of coupling coefficient and mutual inductance. This in turn leads to the higher level of power transferred between these coils. This has been shown by exciting one of the designed coils, developed from obtained solution, and measuring the uncompensated apparent power at the terminals of the other coil which has been found to be higher for higher values of k. The developed design procedure can be used in inductive power transfer systems where the coupling coefficient needs to be maximized while keeping the system dimensions within limits. This procedure can also help in making better decisions on such system's parameters which is difficult and time consuming otherwise.

Reference

[1] Andrew R. Conn, Katya Scheinberg, Luis N. Vicente, Ch 2, “Introduction to Derivative-Free Optimization”, MPS-SIAM Series on Optimization, 2008.

Figures used in the abstract

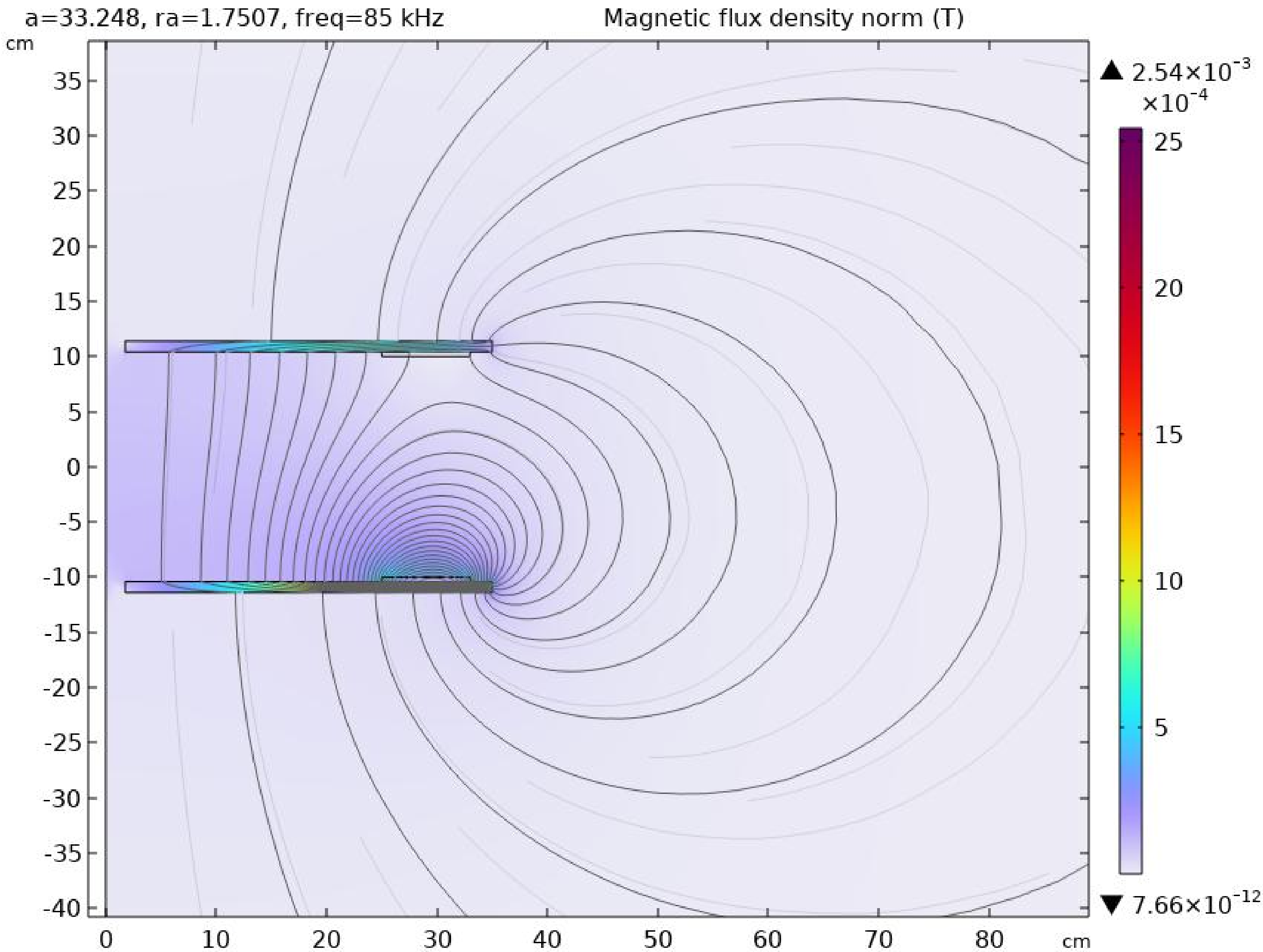

Figure 1 : Optimized geometry

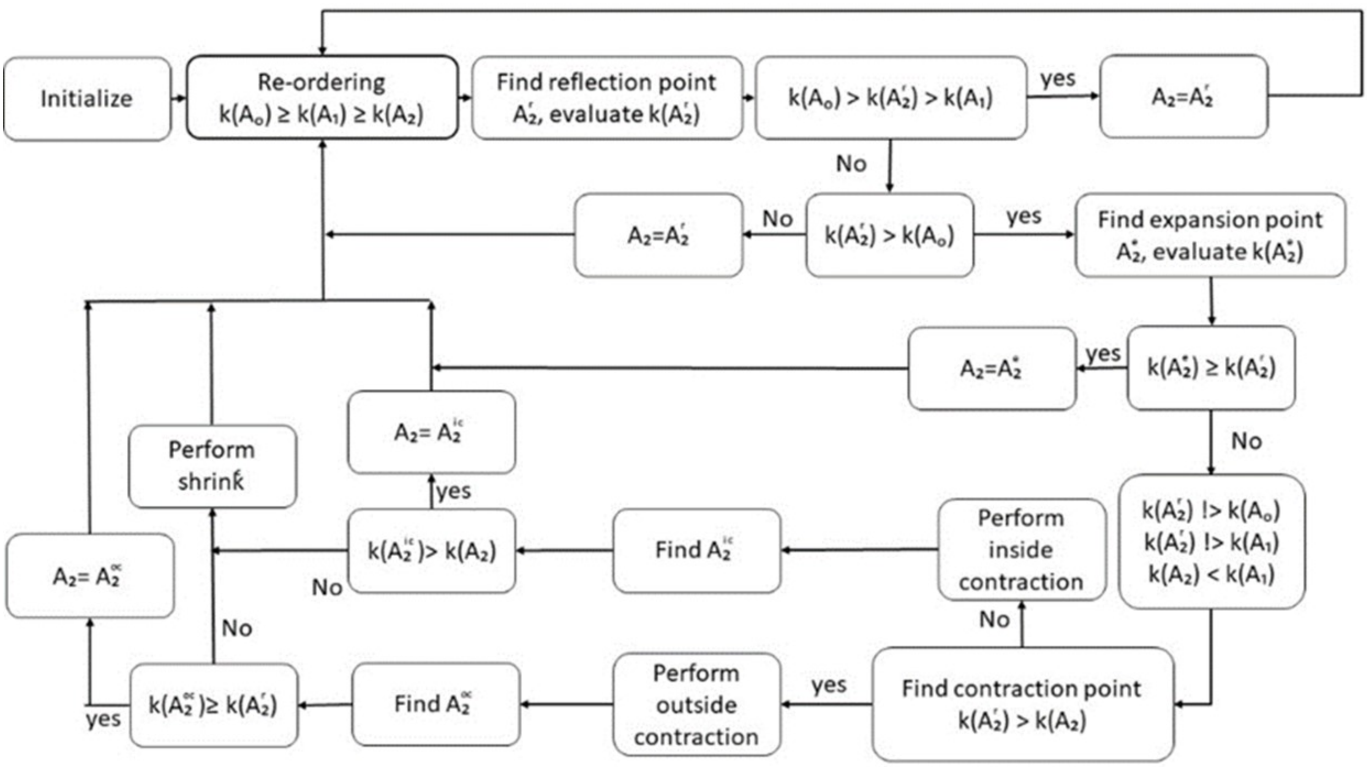

Figure 2 : NM Simplex algorithm for 3 variable objective function maximization

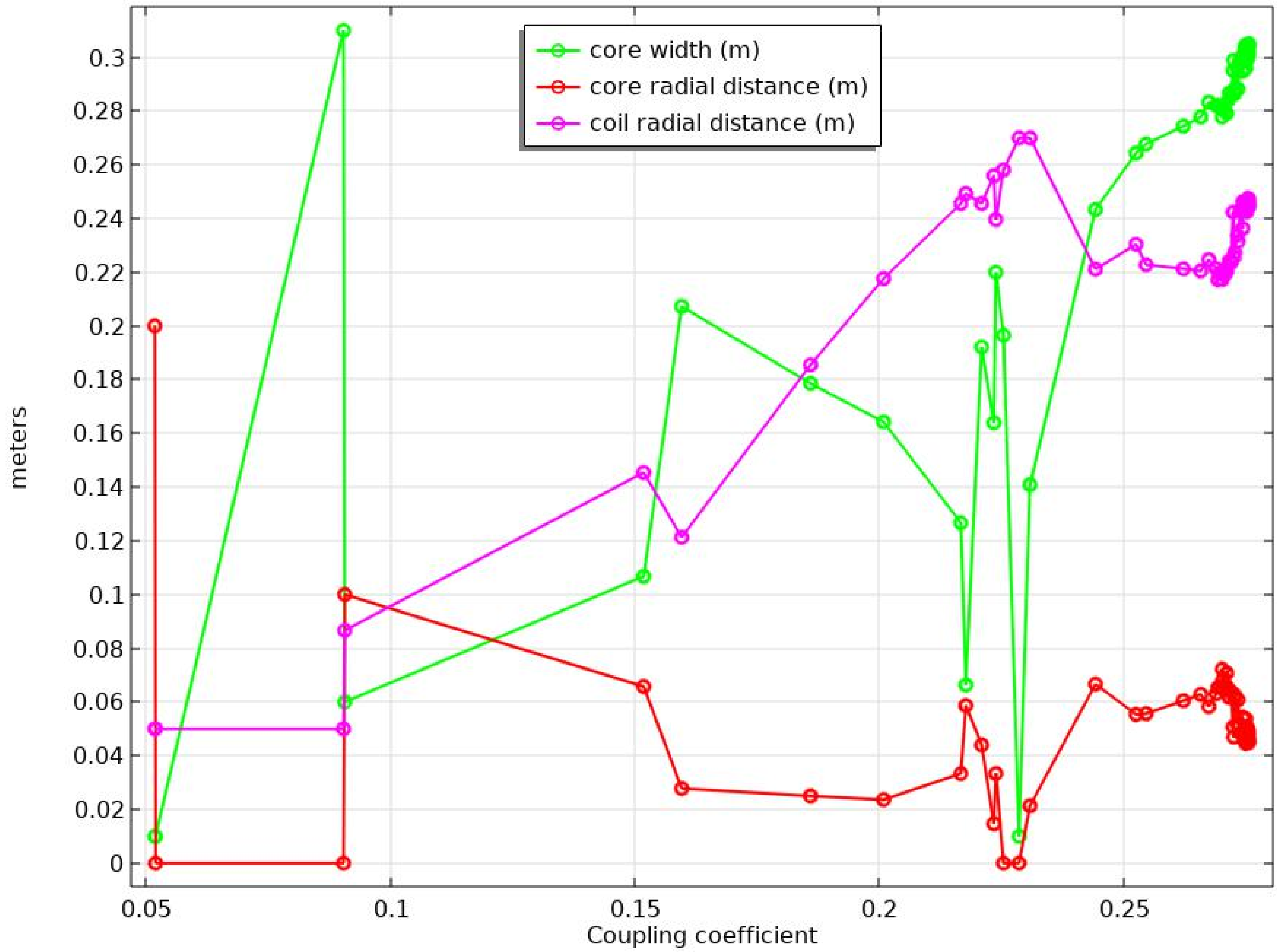

Figure 3 : Path taken by each variable in search routine

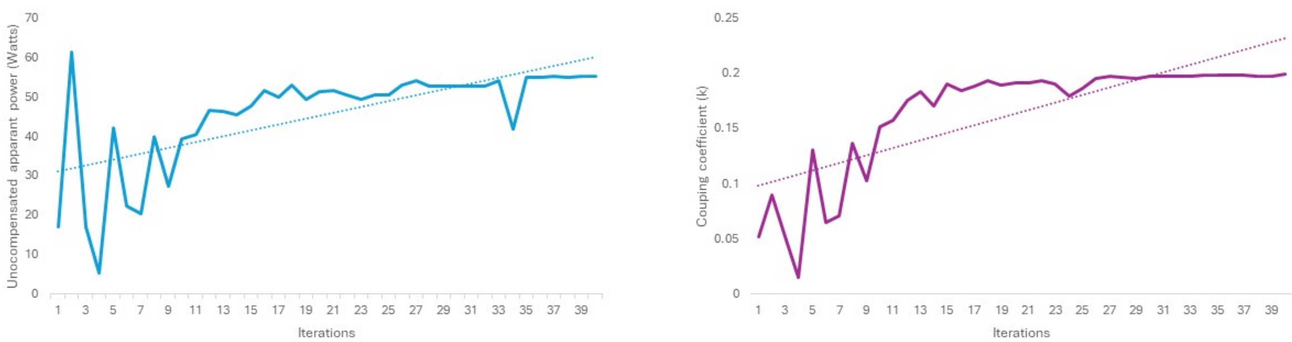

Figure 4 : Uncompensated Apparent Power and Coupling Coefficient