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Shape Optimization Methods for the Design of Microwave Circuits and Antennas

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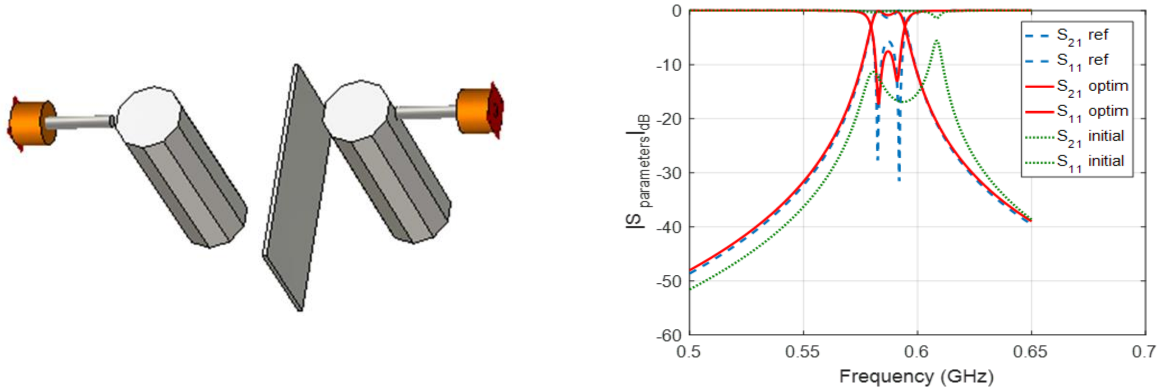
Shape optimization techniques allow improving the performance of a device by changing its geometrical or topological parameters, pushing the limits of classical designs. Like any optimization method, shape optimization techniques converge towards an optimal solution, based on the computation of a cost function related to the response of the device (S parameter, directivity …) after modifying a set of parameters that control the size, the boundary or the topology of its components in the optimization domain.

Several shape optimization techniques, including level-sets, topological gradient methods or genetic algorithms, have been coupled with numerical EM field solvers for optimizing microwave components and circuits. Practical application examples have been detailed in [1], [2] and [3].
In general, such techniques allow improving an initial solution, but the drawback is the huge number of variables to be handled with the numerical model, leading to a very slow optimization process, with no guarantee of finding the global optimum.

In order to relax this constraint, a new parameterization of the contours, based on Bézier curves is proposed. The advantage of such polynomial approach is to represent a wide diversity of shapes with a reduced number of variables, allowing both global and local optimization strategies.
Preliminar tests have been performed, considering metallic cavities loaded by cylindrical posts, as described in Fig. 1 (a). A reference response has been defined, and a gradient-based algorithm has been implemented and tailored to ensure a very good convergence regardless of the circumference of the post, as shown in Fig. 1 (b).



(a) (b)

Figure 1. (a) Test-case for Bézier curve parameterization, (b) Optimization results

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2. H. Khalil, et al., "Topology Optimization Applied to the Design of a Dual-Mode Filter Including a Dielectric Resonator," *IEEE MTT-S International Microwave Symposium Digest*, art. no. 4633035, pp. 1381-1384, 2008

3. A. Assadihaghi, et al., "Design of Microwave Components Using Topology Gradient Optimization," *European Microwave Conference*, art. no. 4057850, pp 462-465, 2006