

# Topology Optimization of Antennas and Waveguide transitions

**Emadeldeen Hassan**

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**Author**

Emadeldeen Hassan

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Topology Optimization of Antennas and Waveguide Transitions

**Abstract**

This thesis introduces a topology optimization approach to design, from scratch, efficient microwave devices, such as antennas and waveguide transitions. The design of these devices is formulated as a general optimization problem that aims to build the whole layout of the device in order to extremize a chosen objective function. The objective function quantifies some required performance and is evaluated using numerical solutions to the 3D Maxwell's equations by the finite-difference time-domain (FDTD) method. The design variables are the local conductivity at each Yee edge in a given design domain, and a gradient-based optimization method is used to solve the optimization problem. In all design problems, objective function gradients are computed based on solutions to adjoint-field problems, which are also FDTD discretizations of Maxwell's equations but solved with different source excitations. For any number of design variables, the computation of the objective function gradient requires one solution to the original field problem and one solution to the associated adjoint-field problem. The optimization problem is solved iteratively using the globally convergent Method of Moving Asymptotes (GCMMA).

By the proposed approach, various design problems, including tens of thousands of design variables, are formulated and solved in a few hundred iterations. Examples of solved design problems are the design of wideband antennas, dual-band microstrip antennas, wideband directive antennas, and wideband coaxial-to-waveguide transitions. The fact that the proposed approach allows a fine-grained control over the whole layout of such devices results in novel devices with favourable performance. The optimization results are successfully verified with a commercial software package. Moreover, some devices are fabricated and their performance is successfully validated by experiments.

**Keywords**

Topology optimization, adjoint-field problems, Maxwell's equations, finite-difference time-domain method, sensitivity analysis, antennas, waveguides, ultra-wideband antennas,

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