Topology optimization of radio frequency and microwave structures

This thesis focuses on topology optimization of conductor-based microwave and radio frequency electromagnetic devices. The research is motivated by the ever increasing usage of small hand-held, or autonomous, electric devices, which have lead to a series of new challenges for the design of efficient antennas and power supplies. A topology optimization methodology is proposed based on a design parameterization which incorporates the skin effect. The numerical optimization procedure is implemented in Matlab, for 2D problems, and in a parallel C++ optimization framework, for 3D design problems. The optimization procedure is first applied to the design of energy focusing devices. The examples cover 2D and 3D resonators, which can be thought of as simplified energy harvesting systems. This is followed by a more practical example, in which the design and optimization of Fresnel plate zone lenses are investigated. It is shown that the performance can be increased with more than 30% compared to a conventional design. The second optimization problem investigated concerns the design of sub-wavelength antennas. In order to alleviate dependence on the initial design and to obtain a generally applicable design formalism, a two step optimization procedure is presented. This scheme is applied to the design and optimization of a hemispherical sub-wavelength antenna. The optimized antenna configuration displayed a ratio of radiated power to input power in excess of 99%. The third, and last, design problem considered in this thesis, concerns the optimization of devices for wireless energy transfer via strongly coupled magnetic resonators. A single design problem is considered to demonstrate proof of concept. The resulting design illustrates the possibilities of the optimization method, but also reveals its numerical limitations with respect to the resolution of the different length-scales involved.