

TOPOLOGY OPTIMIZATION OF RF ELECTROMAGNETIC DEVICES USING DG-FEM

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Abstract

The pursuit of efficient broadband control of radio-frequency devices, such as antennas and waveguides, is historically based on known structural elements. This often leads to heavy and large devices, which is a significant drawback for space applications. Moreover, the analysis required for broadband control is computationally demanding, and when treated in the frequency domain it becomes problematic due to the indefiniteness of the resulting system matrices.

This work attempts to tackle both shortcomings by using an efficient time-stepping scheme based on higher-order Discontinuous Galerkin Finite Element Methods, executed on GPUs and utilizing the Fast Fourier Transform to express the optimization problem in the frequency domain. Sensitivities are obtained using the standard adjoint method, run backwards in time, and checkpointing is employed due to the limited memory available on GPUs. The overall focus of the work is the design of compact and broadband waveguide filters.

To stabilize the optimization process, filtering is applied to the time-domain signals to mitigate Gibbs oscillations that arise from the use of higher-order basis functions. Broadband control is achieved by exciting the system with a square-wave input signal, which efficiently activates a wide range of frequencies within a single time-domain simulation. The optimization objectives are formulated by sampling the fields at multiple points on the input and output ports, allowing direct control of transmission and reflection properties across the target frequency range and desired propagating modes.

The proposed framework is demonstrated through numerical examples involving the design of compact low-pass and band-pass waveguide filters. These examples illustrate how the method combines broadband performance with reduced physical footprint, while maintaining computational efficiency through GPU acceleration and time-domain evaluation of frequency-domain objectives.