Data-driven Model Order Reduction for Fast Frequency Sweep in Hybrid BI-FEM Domain Decomposition Solution in Large Finite Frequency Selective Surfaces

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Full-wave solution of electrically large finite Frequency Selective Surfaces (FSS) is a challenging numerical problem that can be addressed by a hybrid Boundary Integral-Finite Element Method (BI-FEM) Domain Decomposition approach, where an appropriate preconditioner can be applied for accurate solution of the large electromagnetic problem.

However, the computational effort to be taken into account for a single frequency analysis is already large enough, and a specific electrical behavior in a given frequency band is to be designed for engineering purposes. In order to compute the frequency behavior, a reduced-order model is prefered rather than computationally expensive frequency point analyses.

In this solution setting, the frequency dependency in the preconditioned numerical matrix operators to be solved is involved enough to apply standard model order reduction techniques, such as Asymptotic Waveform Expansion (AWE), Padé via Lanczos, Proper Orthogonal Decomposition (POD) or Reduced Basis Method (RBM), where a reduced-order projection space is appropriately built up taking advantage of the specific parameter dependence. As a result, we propose to build up a reduced-order model by the only means of the output scattering data provided by our solver, which will therefore be used as a black-box in terms of the model order reduction process.

This data-driven reduced-order model is based on the Loewner matrix approach. This technique builds a linear dynamical system fitting the data and, not only the frequency band behavior of the FSS is determined, but also, we place special emphasis in getting a linear dynamical system description of the physics in the FSS such that we can use this information for design purposes.

Several numerical examples will illustrate the capabilities of this approach and FFS in planar settings as well as in radomes will be considered.