A Generalized Scattering Matrix Approach for Using Transformation Electromagnetics to Design Electromagnetic Devices

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In this paper, we take a new look at the problem of designing practical electromagnetic devices, such as reflectarrays, flat lenses, and absorptive coatings for scattering reduction. Currently, one of the most popular approaches to solving these design problems is based on the use of Transformation Electromagnetics, *aka* Transformation Optics (TO). However, one of the caveats of using the TO is that the material parameters (ε, μ) called for by the TO algorithm may be difficult to realize in practice without using metamaterials that are known to suffer from polarization sensitivity, angle selectivity and limited bandwidth issues.

To mitigate some of the problems mentioned above, we propose an alternative algorithm based on Field Transformation, implemented in the framework of the Generalized Scattering Matrix approach (see Fig.1), which transforms the electromagnetic field distribution in an input port, generated by a given source distribution, to a desired distribution in the exit port. We differ from the TO approach in that for the case of the Lens and Reflectarray problems we specify only the desired Phase of S_{21} without being concerned about its magnitude, whereas for the scattering reduction problem the objective focuses on controlling only the Magnitude of S_{11}. In contrast, Transformation Electromagnetics imposes significantly more stringent conditions on both the magnitude and phase characteristics of S_{11} and S_{21}, which in turn leads to the difficulties we have mentioned above. The Scattering Matrix/Field Transformation approach circumvents these problems altogether and, what is perhaps even more significant, this strategy enables us to use ε-only materials for the lens and reflectarray problems, and realizable complex materials that have wideband characteristics (e.g., materials realized by using the Dial-a-Dielectric method) for scattering reduction problems.

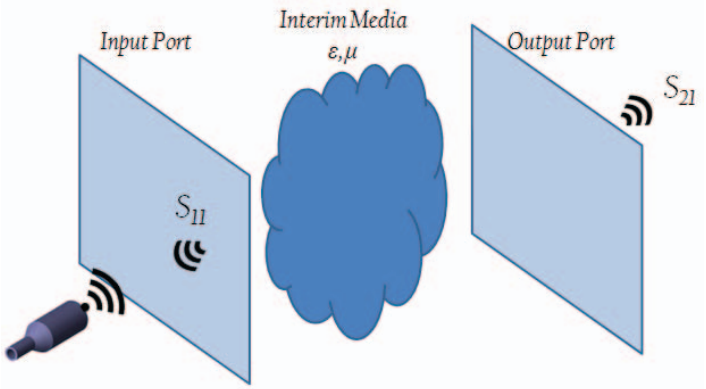

Fig.1. Generalized Scattering Matrix approach in the context of the Field Transformation (FT) method.