Modeling Tunable Near Field Filter Systems with a Coupling Matrix Extracted from a Full-Wave Simulation

Andrew T. Wegener*, William J. Chappell
Purdue University, W. Lafayette, 47906, https://engineering.purdue.edu/IDEAS

Coupling matrices are often used to design modern microwave filters. They are useful, as they can directly relate the coupling strengths of a set of coupled resonators to the filter response. However, given a physical filter geometry it can be difficult to find the exact terms of the coupling matrix from traditional measurements.

In this paper, a technique is introduced to extract the coupling matrix from a full-wave field simulation of a filter structure. This extraction technique incorporates a direct method for determining the loss in the filter. Both the loss in the resonators and the loss in the coupling terms are extracted directly from the full-wave simulation.

The extraction technique presented here is based on the ability to probe the individual resonators of a filter in a full-wave simulation. This probing is accomplished by careful placement of lumped ports in each of the filter's resonators. The result of a simulation with such probes will be an admittance matrix relating the coupling of each resonator to every other resonator, and to both the input and output of the filter. The coupling matrix of the filter can then be directly extracted from this admittance matrix.

This technique is similar to one demonstrated by Xinshe Yin (Xinshe Yin, *Symposium Digest (MTT) 2012*). However, the technique presented by Yin does not account for either loss in the resonators or the couplings between the resonators. The technique presented here includes both loss mechanisms. Results will be shown comparing the scattering parameters extracted from the coupling matrices of both techniques (with and without loss) to the scattering parameters obtained directly through full-wave simulations and measurements.

The structure that will be used for this demonstration is a tunable near-field filter with six resonators used to isolate two antennas from each other. In this structure, the antennas (which are stacked patch antennas) are also modeled as resonators in the filter structure. Since they are designed to radiate, modeling their "loss" is essential to create a good model of the system. The coupling matrix extracted using the method presented here matches the full-wave simulation (which has been shown to match the measured response) quite well. This coupling matrix will make it possible to modify the design of these near-field filters to give better filter responses.