Computation of the Scattering Parameters of a System of Waveguide Sections Using a Recursion Technique

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Multiply cascaded waveguide junctions have been long employed to create microwave transitions, filters and transformers. In these devices, dissimilar but uniform waveguide sections are connected at a junction plane. Analysis of cascaded waveguide sections can be undertaken by extending classic 2-port theory to multimodal systems, but directly cascading ABCD or T matrices leads to difficulty because of the need to invert ill-conditioned matrices. To overcome this, researchers have considered using recursive approaches, propagating an input through the system one section at a time (O.P. Franza and W.C. Chew, IEEE Trans. on MTT, 87-92, 1996). Unfortunately, existing formulations do not allow for much physical insight into the problem being analyzed.

We propose a much simplified recursive technique that uses the reflection and transmission modal coupling matrices at each junction. These matrices may be found using any convenient technique, such as moment method or finite element analysis. We describe how the junction matrices may be found using mode matching and put into a particularly simple and compact form. A specific example of a capacitive step is used as an example that is applicable to designing sample holders for waveguide material characterization systems. Comparison of the S-parameters computed using the recursive technique to results obtained from HFSS are given for a simple waveguide iris. Results are also compared to measurements made for a 3-D printed waveguide section containing an iris. Finally, an extrapolation technique is described that allows the computation of highly accurate S-parameters using far fewer modes than standard mode matching. This technique is applied to a waveguide sample holder consisting of a sample region sandwiched between two waveguide irises.