

## Design of Mode Converters Using the Coupled-Integral-Equations Technique

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Mode converters in circular waveguide are widely used in high-power microwave and horn antenna applications. Several designs to convert a TE/TM<sub>m</sub>n to a TE/TM<sub>k</sub> mode have been presented and, among the varieties of mode converters, those involving the special case of rotationally symmetric structures with  $m=i$  have attracted special attention. However, general design methods or design guidelines are available only very sparsely.

This paper closes that gap. Based on the coupled-integral-equations technique (CIET) as an accurate analysis tool, a synthesis approach for the design of rotationally symmetric mode converters is developed as follows:

1. The diameters of input and output guides are chosen such that the wavelength of the two modes involved are identical.
2. The power transmitted from the incident to the output mode, i.e., the magnitude squared of the coupling integral between the two modes, is analyzed with respect to maximum excitation of the desired output mode.
3. The number of required discontinuities is determined from the desired efficiency of the mode converter.
4. The entire length is adjusted to encompass one wavelength at midband frequency.

The approach is demonstrated at the example of a TE<sub>11</sub>-to-TM<sub>11</sub> converter. Using the above guidelines, the initial design achieves a 90 percent conversion efficiency over a 3.6 percent bandwidth with 13 dB minimum return loss. After optimization using MiniMax strategies, and the CIET for analysis, the efficiency is better than 99 percent over a 5.5 percent bandwidth with return loss better than 20 dB; or better than 96 percent over a 20dB-return-loss bandwidth of six percent. All results obtained by the CIET are verified by the mode-matching technique and/or the finite-element method. Performance claims in a recent publication could not be verified by any one of these three numerical methods. For high-power applications, the investigation shows that the performance is not degraded by rounding the corners of the discontinuities involved.

The presentation will focus on the design guidelines (and their rationale) for conversion from TE<sub>m</sub>n to TE/TM<sub>k</sub> modes with emphasis on mode-converter and horn-antenna applications.