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Analysis and design of large leaky-mode array employing the coupled-mode approach

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This paper presents the coupled-mode approach to the analysis and design of a large leaky-mode array, in which an N-element microstrip array above a common ground plane supports N coupled leaky modes (leaky EH/sub 1/ modes) at the first higher order. Following a brief description of a conventional full-wave nonstandard eigenvalue problem for solving the complex propagation constants, we present the detailed formulation of the coupled-mode approach, clearly showing the transformation of the nonstandard eigenvalue problem into a standard one. Thus, all the eigenvalues (complex propagation constants) and eigenvectors (modal current distributions) are solved simultaneously, regardless of the size of the array (N). Two key issues pertinent to the successful implementation of the proposed coupled-mode approach are addressed: the determination of the coupling coefficients and the uniqueness of the isolated uncoupled leaky mode, which represents the leaky modal solution of a single microstrip, but is derived from a system of coupled leaky-mode solutions provided the coupled microstrips have equal width and spacing. Closed-form expressions for obtaining the coupling coefficients of orders two, three, and four are presented. Theoretical studies of closely coupled microstrip arrays of two, three, and four elements show that the magnitude of the coupling coefficient /sub i,i+j/ between elements i and i+ decreases at the order of 10/sup -j/. These theoretical case studies also lead to the same isolated uncoupled leaky-mode solution as predicted. Furthermore, the dispersion characteristics of the microstrip array at the first higher order obtained by the coupled-mode approach and the full-wave approach agree excellently for all the case studies. Error analyses indicated that at least two coupling coefficients (C/sub i,i+1/ andC/sub i,i+2/) are required for obtaining accurate complex propagation constants with rms errors less than 1% for most of the leaky region of the particular array under investigation. An example of applying the proposed coupled-mode- approach for analyzing a corporate-fed leaky-mode array of eight elements is reported, revealing that only four out of the eight leaky modes are excited. The coupled-mode theory predicts the far-field radiation pattern in the main beam region in excellent agreement with the measured results.

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