SPECTRAL ITERATIVE TECHNIQUE FOR ANALYZING MULTICONDUCTOR MICROSTRIP LINES

C. Chan and R. Mittra

University of Illinois
Urbana, Illinois

ABSTRACT

The spectral-iterative technique is used to analyze multiconductor microstrip lines. The iteration procedure is based upon the conjugate gradient technique applied in the spectral domain and employs the FFT algorithm for efficient computation. Numerical results are presented and compared with available data.

Microelectronic packaging plays an important role in the present state-of-the-art high speed digital computers. A major source of speed delay in the central processing unit of many computers is the time needed to transfer information signals from one logic device to another. To circumvent this, electric power and information signals are usually distributed through microstrip lines compactly printed on PC boards. The layout of the microstrip lines must be designed to minimize the cross-talk which becomes more serious as switching speeds are increased and dimensions are reduced.

Coupled microstrip lines have been analyzed by Wheeler [1] with conformal mapping, Bryant and Weiss [2] with dielectric Green's function, Yamashita and Mittra [3] with variational method, and Rahmat-Samii, Itoh, and Mittra [4] with Galerkin's method in the spectral domain. However, none of the above methods can be modified easily to treat more than two lines, or eventually N lines. In this paper we use the spectral iterative technique (SIT) [5] in conjunction with the conjugate gradient method [6] to analyze multiconductor microstrip lines. The quasi-static approximation is employed [1-4].

Figure 1 shows the geometry of the structure to be analyzed. The most significant parameters needed to calculate the cross-talk of the structure are the matrices of Maxwell's coefficients of capacitance and the line coefficients of inductance. These can be easily obtained if the charge distribution and the current distribution on the microstrip lines are known for different excitations. The integral equation describing the problem can be written as:

$$Y(x) = \int_D G(x,x')\, X(x')\, dx', \quad x \in D \tag{1}$$

$$X(x) = 0, \; x \notin D \tag{2}$$

where D corresponds to the intervals on the x-axis which coincide with the microstrip lines. Y(x) represents the specified voltages on the strips and $\tilde{G}$ is the spectral domain Green's function which is assumed known. Thus, the only unknown in equation (1) is X(x), the charge distribution on the strips.

An iterative algorithm for solving equation (1) is constructed by defining an error criterion as follows:

$$F(x) = Y(x) - \int_D G(x,x')\, X'(x')\, dx' \tag{3}$$

$$\text{ERROR} = \int_D |F(x)|^2\, dx \tag{4}$$

where X'(x') represents an intial guess. The updated X' is generated by applying the boundary condition (2) in conjunction with the conjugate gradient method and the new X' is then used as the initial guess for the subsequent iteration. This procedure systematically and monotonically improves the accuracy of the solution and is repeated until the ERROR is sufficiently small.

The convolution operation in equation (1) is carried out in an efficient manner in the spectral domain using the FFT as follows:

$$\int_D G(x,x')\, X'(x')\, dx' = F^{-1}\{\tilde{G}\cdot F[X']\} \tag{5}$$

where F and F^{-1} represents forward and inverse Fourier transforms respectively.

The present method has several important advantages over the presently available techniques. Some of these are listed below:

1. The initial guess X' can be very simple and can even be chosen as zero. Thus, no elaborate search for appropriate basis functions need be carried out.

2. The accuracy of the results can be readily improved by simply increasing the number of sampling points rather than the number of basis functions as in conventional methods.

3. It is extremely straightforward to change the parameters of the system, e.g., the number, width, spacing, etc. by simply redefining the domain D.

Numerical results for the characteristic impedance of a single microstrip line and the even and odd mode characteristic impedances for two coupled microstrip lines are shown in Figures 2 and 3 where comparison with previously available results are also presented. New results for 3 or more coupled lines will be presented.

REFERENCES

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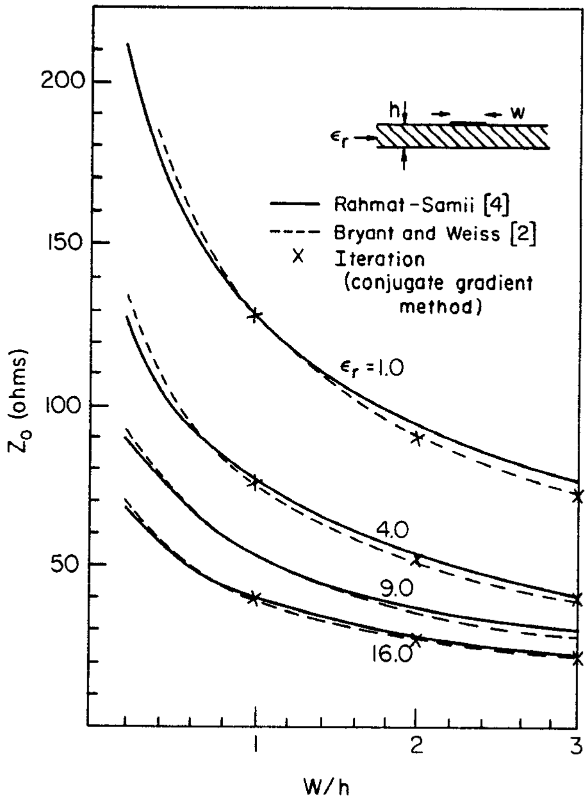

Figure 2. Characteristic impedance of a uniform microstrip.

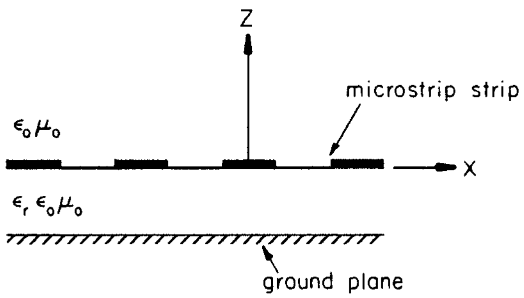

Figure 1. Microstrip structure.

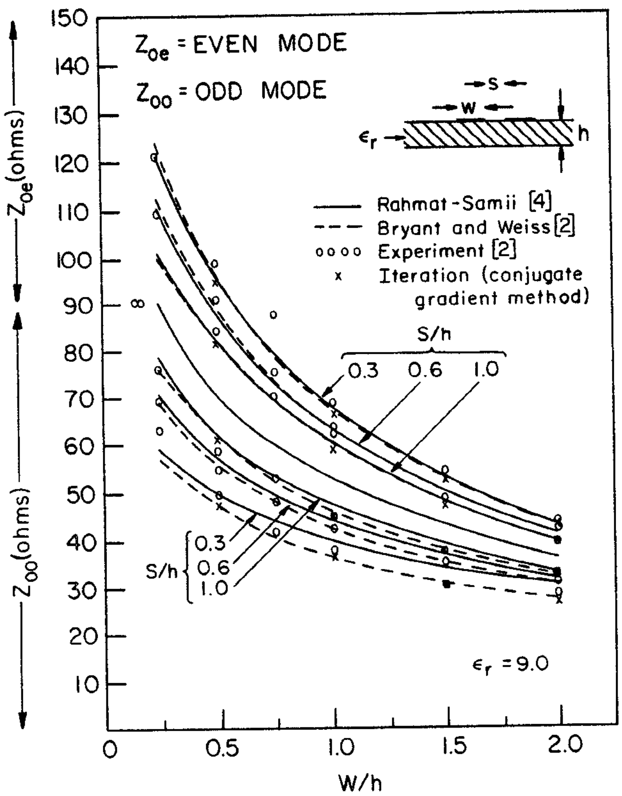

Figure 3. Characteristic impedance of coupled pairs of microstrip transmission lines.