Correction to "Computation of Lumped Microstrip Capacities by Matrix Method—Rectangular Sections and End Effect"

ANDREW FARRAR AND A. T. ADAMS

In the above correspondence,[1] (1) is difficult to interpret in the form given. In this equation, the field point (x_i, y_i, z_i) is at the edge of subsection ΔS_i, and the source point (x_j, y_j, z_j) is at the center of subsection ΔS_j. Also, to (1) should be added a negative expression similar to that given in the brackets with $(2n-2)^2$ replaced by $(2n)^2$, in order to include the images below the ground plane.

For wide strips $(W/H > 2.5)$, the data in Fig. 4 were found to be in error due to computational difficulties. The computational method has been improved, and the corrected data are shown in Fig. 1.

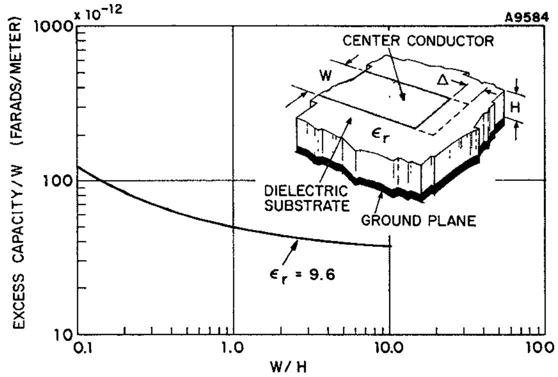

Fig. 1. Excess capacity of open-circuited microstrip.

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[1] A. Farrar and A. T. Adams, *IEEE Trans. Microwave Theory Tech.* (Corresp.), vol. MTT-19, pp. 495–496, May 1971.

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Computer Program Descriptions

FINPLT: A Finite-Element Field-Plotting Program

PURPOSE: FINPLT draws smooth contours on a Calcomp digital plotter for any surface for which potential values are known on an arbitrary set of points.

LANGUAGE: Fortran IV, G level; source deck length 750 cards.

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AVAILABILITY: ASIS—NAPS Document No. NAPS-01705. Copies of the source deck may be purchased from the authors for U. S. $20.

DESCRIPTION: FINPLT was written to complement the authors' dielectric-loaded waveguide-analysis program [1], and utilizes a compatible geometrical data format. Accordingly, the field region must be divided into triangular elements, as described in [1], and the potential values specified on a set of Newton–Cotes interpolation nodes for each element.

In applications to fields arising from other sources, it is best to first generate the interpolation point set with the sophisticated geometric routines in FINPLT and then determine the potential values corresponding to it.

PRINCIPLE OF OPERATION

By using two-dimensional Newton–Cotes interpolation polynomials, any function of two independent variables may be approximated in any polygonal region by dividing the region into triangles. Although these polynomials may be written to an arbitrary order, only second-order polynomials accommodate a simple algorithm that yields curved contours. In standard quadratic form, taking $\{\zeta_i\}$ to be triangular coordinates, $\{\phi_i\}$ to be the potential values at the interpolation points, and P to be the potential, this polynomial is

$$\zeta_i^2 A_i + \zeta_i(B_{1i} + \zeta_j B_{2i}) + (P + C_{1i} + \zeta_j C_{2i} + \zeta_j^2 C_{3i}) = 0 \qquad (1)$$

where $i = 1, 2, 3, j = i \bmod (3) + 1$, and

$$\begin{aligned} A_i &= 2(\phi_a + \phi_f - 2\phi_c) \\ B_{1i} &= -\phi_a - 3\phi_f + 4\phi_e \\ B_{2i} &= 4(\phi_f + \phi_b - \phi_c - \phi_e) \\ C_{1i} &= \phi_f \\ C_{2i} &= 4\phi_e - \phi_d - 3\phi_f \\ C_{3i} &= 2(\phi_d + \phi_f - 2\phi_e). \end{aligned}$$

Here, (a, d, f) and (b, c, e) are the ith cyclic permutations of (1, 4, 6) and (2, 3, 5), respectively. By setting P equal to a constant in (1) and using the relationships

$$\begin{aligned} x &= x_1\zeta_1 + x_2\zeta_2 + x_3\zeta_3 \\ y &= y_1\zeta_1 + y_2\zeta_2 + y_3\zeta_4 \\ \zeta_1 &+ \zeta_2 + \zeta_3 = 1 \end{aligned} \qquad (2)$$

where (x_i, y_i) are the coordinates of the ith vertex of the triangle, (1) can be solved for the locus of points on the equipotential contour.

Although first- to fourth-order finite-element triangles may be supplied as data, in order to use (1), FINPLT determines N^2 second-order subelements in each Nth-order element by evaluating the coordinates and potential values for a set of points midway between the previous set. In each subelement, the intersections of the potential with the sides of the triangular subelement are determined and the three triangular coordinates stepped off in specified intervals, from the smallest value found with the intersection of the potential with the sides to the largest.

Since a quadratic expression is solved, the equipotential contours are not necessarily single-valued at any value of the x coordinate. Many ways of distinguishing points on the upper and lower branches of the contours have been considered, but none have proved to be fool-

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For program listing, order NAPS-01705 from ASIS National Auxiliary Publications Service, c/o CCM Information Corporation, 909 Third Avenue, New York, N. Y. 10022; remitting $2.00 per microfiche or $5.00 per photocopy.

proof in all cases. The method used in FINPLT is to take each point and compare its coordinates to the point with the next larger value of the x coordinate. If both the x and y coordinates of the next point are close enough to that of the first point, then the point is accepted to be plotted on that line; if it is too far from the first point, it is left to be plotted on another line.

Clearly, the success of this method is dependent on the value of "close enough" used in the process. In FINPLT the value used is three times the maximum minus the minimum coordinate divided by the number of steps of triangular coordinate taken.

Results and Computing Times

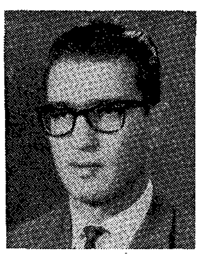
Examples of the type of results FINPLT produces may be found in [2], [3] where all of the field plots were drawn by FINPLT. Notice that the contour plots are perfectly smooth for well-behaved fields, but that discontinuous changes in the derivative can occur in regions where the field changes rapidly. This is not the fault of FINPLT, but indicates that too few finite-element triangles were used to approximate the field in that region.

In order to do a typical plot, say a six fourth-order triangle problem with 30 equipotential lines, FINPLT requires about 30 s of central processing unit (CPU) time on an IBM 360/75 and about 6 min of time on a Calcomp 663 digital plotter.

References

[1] Z. Csendes and P. Silvester, "Dielectric loaded waveguide analysis program," *IEEE Trans. Microwave Theory and Tech.*, vol. MTT-19, p. 789, Sept. 1971.
[2] ——, "Numerical solution of dielectric loaded waveguides: I—Finite-element analysis," *IEEE Trans. Microwave Theory Tech.* (*1970 Symposium Issue*), vol. MTT-18, pp. 1124–1131, Dec. 1970.
[3] ——, "Numerical solution of dielectric loaded waveguides: II—Modal approximation technique," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-19, pp. 504–509, June 1971.

Contributors



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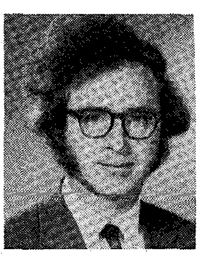

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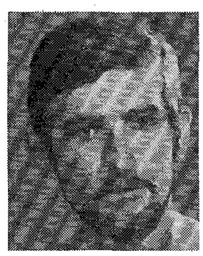

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