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The Effect of Surface Metal Adhesive on Slot-Line Wavelength

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that the modal amplitudes may be readily obtained without having to invert $\langle L^*, L \rangle$ for each α.

The matrices in (5) can be written with the α dependence made explicit in the following way:

$$(M_1 + \alpha M_2)V = (f_1 + \alpha f_2). \tag{6}$$

Since M_1 and M_2 are Hermitian, the weighted eigenvalue equation

$$M_2 v_i = \lambda_i M_1 v_i$$

has real eigenvalues, and its eigenfunctions are orthogonal with respect to the weights M_1 and M_2. Then, substituting

$$V = \sum \beta_i v_i$$

into (6) and multiplying the resulting equation by v_j^* to obtain β_j, we get

$$V = \sum_i \frac{v_i^*(f_1 + \alpha f_2)}{1 + \alpha \lambda_i} v_i$$

assuming normalized eigenvectors (divide v_i by $(v_i^* M_1 v_i)^{1/2}$). A similar expression can be obtained by expanding f_1 and f_2 [10]. Once λ_i and v_i are computed we may obtain V for different values of α. We may also obtain an estimate for α by substituting the propagating modal amplitudes into the expression of the conservation of real power and imposing approximations $|\alpha\lambda_i| \ll 1$ and/or $|\alpha\lambda_i| \gg 1$. Other expressions for V are given in [10].

CONCLUSION

A numerical method for the solution of waveguide discontinuities has been developed here which is suitable for computer implementation and which does not suffer from some of the shortcomings of the other methods. We have solved many problems numerically which do not appear in the extant literature. The method can as well handle other types of waveguides and discontinuities.

The problem that remains to be solved is that of an easier criterion for the selection of the weighting factor (α) so that the smallest possible number of modes can be used for a given accuracy. Davies [5] uses one among several condition numbers of the matrices as the criterion for the selection of α. Such a condition number may be an indicator of the stability of the matrix inversion, but its relation to the equivalent susceptance of the discontinuities and the dominant modal amplitudes remains obscure.

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The Effect of Surface Metal Adhesive on Slot-Line Wavelength

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***Abstract*—An investigation of the dependence of slot-line wavelength upon a thin layer of adhesive between metal and substrate is described. It is shown that the presence of adhesive will cause an increase in wavelength when the dielectric constant of the adhesive is less than that of the substrate. Experimental results are presented which show this dependence for a variety of surfaces and adhesives. A perturbation expression is given which permits correction of experimental data for comparison with theory when this effect occurs.**

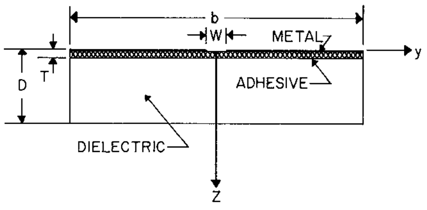

Fig. 1. Slot-line geometry with adhesive.

TABLE I

THICKNESS OF METALS AND ADHESIVES

Metallization	Thickness of Metal (Mils)	Thickness of Adhesive (Mils)
Factory 1 Oz. Copper	1.15	< 1.0
3M Copper Tape	1.25	1.9
3M Aluminum Tape	1.95	1.8
Circuit-Stik Copper Foil	1.15	2.3
Evaporated Copper	0.65	0

I. INTRODUCTION

The analysis of slot line and its microwave applications have been discussed by a number of authors [1]–[7] during the past several years. In one of these papers, Mariani *et al.* [5] presented measured values of slot wavelength for various substrates metallized with both aluminum sensing tape and copper (electroless plated). Their data showed that the slot wavelength on substrates metallized with aluminum sensing tape exceeded the theoretical value. For substrates with copper plated surfaces, the measured wavelength was (with one exception) somewhat less than the theoretical wavelength. It was concluded that the adhesive which was present in the case of aluminum sensing tape decreased the effective dielectric constant and thereby increased slot wavelength.

Measurements in our laboratory substantiate this conclusion. The purpose of this short paper is to present more consistent and extensive data on this effect and to treat the problem using perturbation theory.

II. SLOT-WAVELENGTH MEASUREMENTS

Slot line is constructed by etching a slot utilizing a dielectric substrate which has been metallized on one side only. The metal may be applied in various ways and in some cases a thin layer of adhesive is present between the metal and the substrate as illustrated in Fig. 1. This adhesive may have a significant effect upon the slot wavelength.

A number of experiments were conducted to investigate adhesive effects. In one series of experiments a Custom Materials Hi-K707-20 ($\epsilon_r = 20$) substrate was tested using several different methods of metallization. The substrate was 3-in wide by 0.125-in thick, and slot width was maintained constant in all cases with $W/D = 0.53 \pm 0.02$. The surfaces tested were 1-oz copper as supplied by the manufacturer, 3M copper tape (1-in wide), 3M aluminum tape (1-in wide), and a vacuum deposited copper surface. Table I lists the thicknesses of metal and adhesive for all surfaces tested.

Measured values of λ'/λ for these surfaces are displayed in Fig. 2 along with the theoretical curve from [5]. The vacuum deposited copper surface is in intimate contact with the substrate and the wavelength ratio for this surface may be used as a basis for comparison of experimental measurements. All other surfaces are separated from the substrate by an adhesive layer and increased wavelength ratios result.

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