Computer Program Descriptions

Analysis of Straight Tapered Microstrip Transmission Lines—ASTMIC

PURPOSE: The program ASTMIC calculates the input impedance of straight tapered microstrip transmission lines terminated with arbitrary loads.

LANGUAGE: FORTRAN-IV; 247 cards.

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DESCRIPTION: A straight tapered microstrip transmission line [1], in which the width of the taper varies uniformly over the length of the line, is easy to fabricate and is commonly used as impedance transforming sections in microwave circuit designs. A computer program for the analysis of such lines has been described here. For any fixed degree of taper, the program calculates the input impedance for various frequencies and load impedances.

The program is built around the method, which treats the tapered line as a cascaded combination of a large number of uniform transmission line sections of small length (Fig. 1). This discretization allows the use of usual transmission line equations for the analysis. Starting from the load end, the input impedance of any section is treated as the load impedance of the next section. The input impedance of any section is given by

$$Z_{in_n} = Z_{0_n} \frac{Z_{L_n} + Z_{0_n} \tanh (\alpha_n + j\beta_n)l}{Z_{0_n} + Z_{L_n} \tanh (\alpha_n + j\beta_n)l}. \tag{1}$$

Also

$$Z_{in_n} = Z_{L_{n-1}} \tag{2}$$

and

$$Z_{in} = Z_{in_{n(n=1)}} \tag{3}$$

where

- Z_{in_n} input impedance of the nth section;
- Z_{0_n} characteristic impedance of the nth section;
- Z_{L_n} load impedance of the nth section;
- α_n attenuation constant of the nth section;
- β_n phase constant for the nth section;
- l length of each section;
- Z_{in} input impedance of the microstrip transmission line.

For each section, the characteristic impedance and the phase constant are obtained from Wheeler's expressions [2], [3]. The attenuation constant is obtained from the microstrip line losses [4].

The accuracy of the computation depends on the number of sections chosen. An accuracy criterion has been chosen such that the computer time is not unnecessarily high, while yielding acceptable accuracy. The required number of sections (N) meets the criterion that the computed value of the magnitude of the input impedance for N sections is within 1 percent of the final asymptotic value. The value of N is found from the following empirical relation:

$$N = 70(1 + p) \tag{4}$$

where p is the percentage difference in the calculated values of Z_{in} for 35 and 45 number of sections. This relation was arrived at after many runs of program involving several cases of different degrees of taper and loads.

The value of N required for a desired accuracy is mainly a function of the degree of taper. Normally, the value of N is less than 500, but can be more for very high degrees of taper, such as a tapered line with an end impedance ratio of 50 and an electrical length of less than a wavelength. For all practically encountered tapers, the value of N lies between 70 and 250.

The input parameters for the program are the end characteristic impedances and the physical length of the tapered line, height, and dielectric constant of the substrate, conductivity of the microstrip conductor material, frequencies, and the respective load impedances. The output parameters are Z_{in} real and imaginary, magnitude and phase.

The program does not have any constraints and takes all degrees of taper and load impedances.

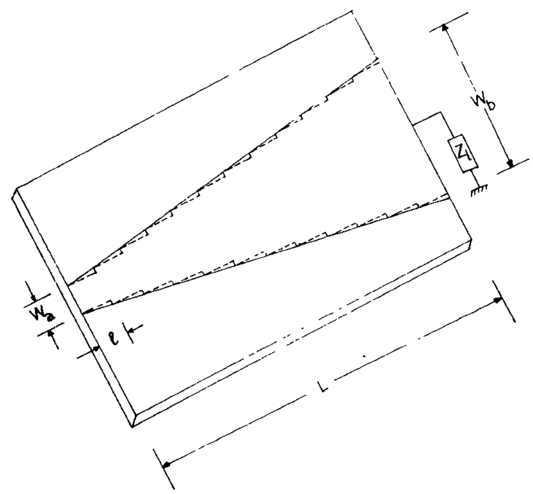

Fig. 1. Schematic diagram of the straight tapered microstrip transmission line showing the division of the tapered transmission line into a number of uniform transmission line sections.

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References

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