CHARACTERIZATION OF COUPLED ASYMMETRIC SUSPENDED STRIP LINES HAVING THREE THICK-STRIP CONDUCTORS AND SIDE-WALL GROOVES

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ABSTRACT

Coupled asymmetric suspended strip lines having three thick-strip conductors and side wall-grooves are characterized with the use of the rectangular boundary division method. An offset broad-side coupling device and a control device of edge coupling with the use of the third strip conductor are discussed as important applications.

I. INTRODUCTION

The characterization of multi-conductor suspended strip lines has become important in microwave and millimeter wave applications such as semi-re-entrant couplers[1] and three-line couplers[2]. Multi-conductor planer transmission lines have been studied by some authors based on the quasi-TEM wave approximation in the past [3][4]. However, these works have not treated coupler structures to be described in this paper.

In this paper, we describe the results of the general characterization of coupled asymmetric suspended strip lines having three thick-strip conductors and side-wall grooves (CASS lines) with the use of the rectangular boundary division(RBD) method[5], because the total region considered here can be divided into rectangular subregions suited to this method. Some numerical results based on this method are compared with those based on conformal mapping[6] for the case of a homogeneous medium. Two important applicationsof our analysis are discussed: the characterization of an offset broad-side coupling device and a control device of edge coupling with the use of the third strip conductor.

II. CHARACTERIZATION OF CASS LINES

Fig.1 shows the cross-sectional view of the CASS lines to be analyzed in this paper with the use of the RBD method. A conductor strip is placed on one side of the suspended substráte and two strip conductors are placed on the other side. It is a merit of the present method that the thickness of thin strip conductors can be easily taken into account in the analysis in contrast to other numerical methods such as the boundary element method.

As the analysis procedure of the RBD method was introduced in detail in a previous paper[5], it is not repeated here. The capacitance matrix for a unit length of the three-strip conductors can be defined as

$$\begin{bmatrix} Q_1 \\ Q_2 \\ Q_3 \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{12} & C_{22} & C_{23} \\ C_{13} & C_{23} & C_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

where Q_1,Q_2,and Q_3, denote the line charge per unit length of each strip and V_1,V_2, and V_3 the line potential of each strip in Fig.1, respectively. The total static field energy in this case is expressed as

$$U = \frac{1}{2} \sum_{i=1}^{3} \sum_{j=1}^{3} C_{ij} V_i V_j$$

By properly selecting six sets of potential distributions, V_1,V_2,V_3, and by using the RBD method, we can obtain the element values of the capacitance matrix.

III. OFFSET BROAD-SIDE COUPLING DEVICE

Fig.2 shows an offset broad-side coupling device with a homogeneous medium. The case of strip conductors of zero-thickness has been treated by Shelton[6] with conformal mapping in the past. The calculated values of the coupling coefficient from the capacitance matrix with the present method agree very well with Shelton's data as shown by solid lines and small circles in Fig.2. The case of thick-strip conductors have also been treated with the present method as shown by solid lines in Fig.2. The CPU time for calculating one coupling coefficient is about 40s on a HITAC-M260D computer.

Fig.3 shows the case of the offset broad-side coupling device of thin- and thick-strip conductors in an inhomogeneous medium. These data are new to the author's knowledge.

IV. CONTROL DEVICE OF EDGE COUPLING

Fig.4 shows the structure of a control device of edge coupling with the use of the third strip conductor. The strip conductor 2 and the strip conductor 3 in Fig.4 have usual functions to couple fields through the capacitance between adjacent two edges.

When the line potential of the strip conductor 1 is not given, namely, the line charge of the strip conductor 1 is set as zero in the capacitance matrix equation, the strip conductor 1 play a role for increasing the capacitance between the two edges of the strip conductors, 2 and 3. Therefore, it can control the edge coupling strength as shown in Fig.5. The coupling coefficient for the case without the strip conductor 1 is also indicated in Fig.5 for comparison.

When the strip conductor 1 has the ground potential, on the other hand, the strength of the edge coupling can be decreased as shown by lower curves in Fig.5.

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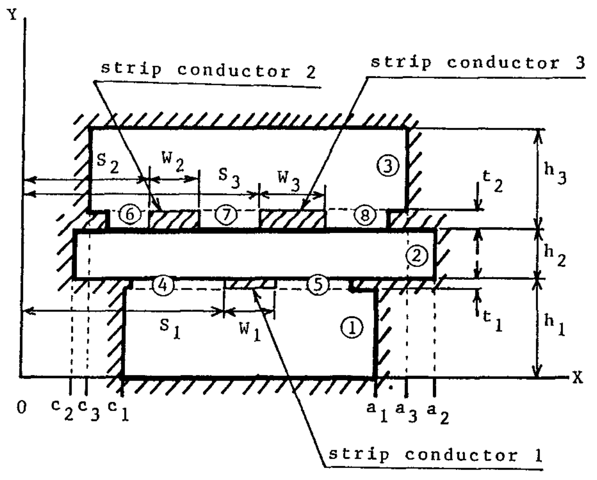

Fig.1 Cross-sectional view of CASS lines

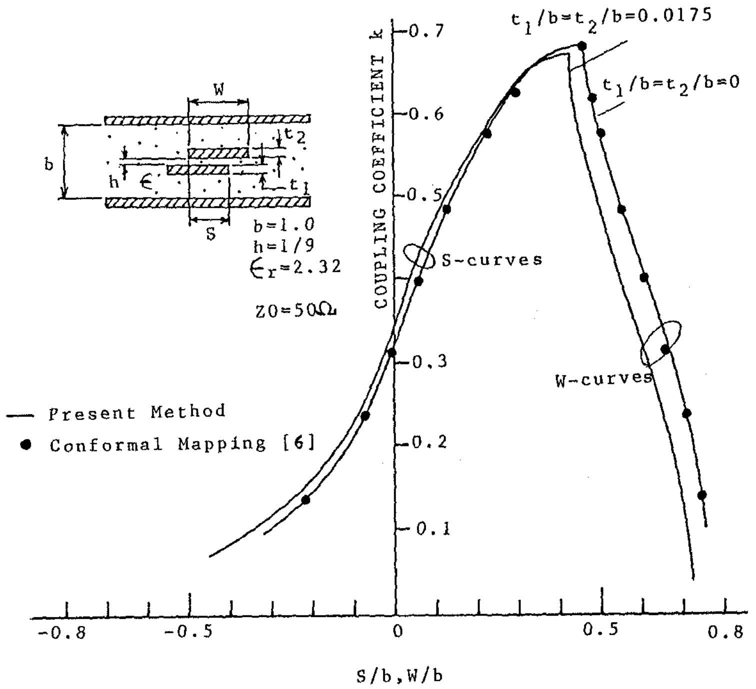

Fig.2 Coupling coefficient of an offset broad-side coupling device with a homogeneous medium

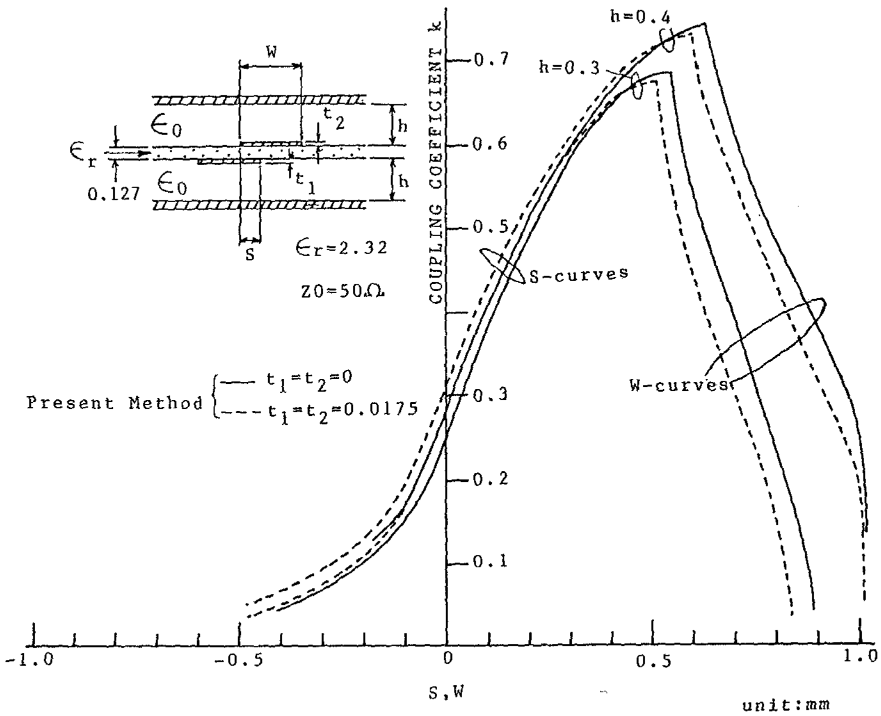

Fig.3 Coupling coefficient of an offset broad-side coupling device with an inhomogeneous medium

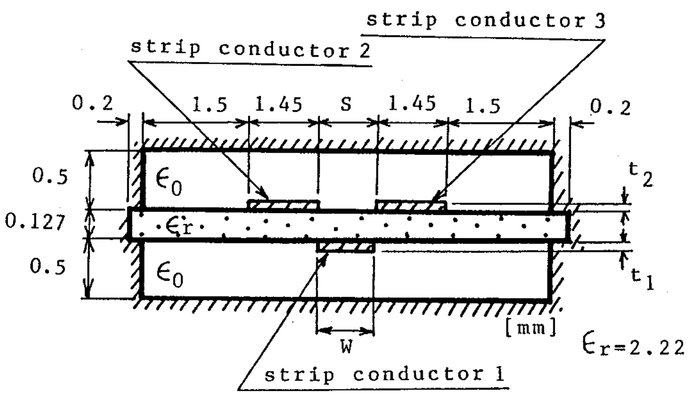

Fig.4 Edge coupling control device with the use of the third strip conductor

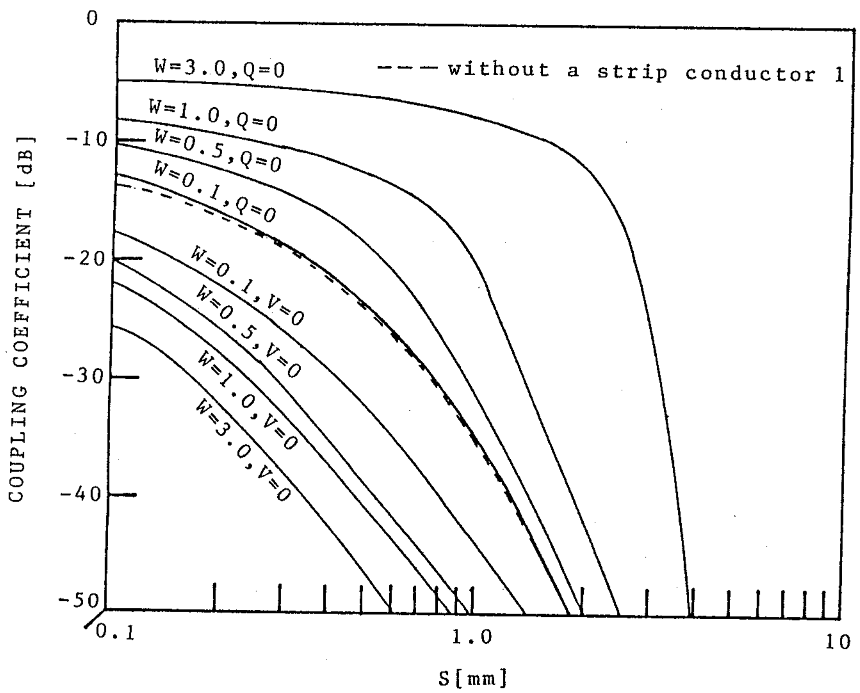

Fig.5 Coupling coefficient controled by the third strip conductor