PACKAGING AND INTERCONNECTION MUTUAL COUPLING EFFECTS IN PLANAR STRUCTURES AND DISCONTINUITIES

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ABSTRACT :

In the present paper, an integral equations technique solved by the method of moment is used to analyse parasitic coupling in general shielded planar structures. Two main ones are studied : the coupling between a planar component and its enclosure and the coupling between planar components themselves.The first effect is illustrated by the calculated values of the effective permettivity of uniform planar lines and the S parameters for a suspended stripline stub discontinuity for different enclosure geometries. The mutual coupling between two small spaced microstrip stubs is also presented and discussed. Comparison with other numerical results as well as with other published experimental ones has verified the accuracy and the numerical efficiency of the present approch.

INTRODUCTION :

In most of existing commercial CAD programs, microwave integrated circuits (MMIC) are often designed without considering different parasitic effects that can occur in practical applications. These effects are essentialy due to coupling either between circuit elements or between the circuit and its enclosure. Few work [1-3] can be found in litterature but the subject is still under developement.

The existence of an enclosure can modify the calculated circuit parameters like the characteristic impedance [4], and the effective permittivity for uniform lines and also the scattering parameters for associated discontinuities. Recently, finite-difference time domain method was used to study the effect of the enclosure on the calculated values of the effective permittivity for a uniform line [5]. The method required relatively high computing time.

In the present work, the effects of packaging on the calculated values of effective permittivity of suspended stripline is presented.The enclosure effect is also well demonstrated in the case of a suspended stripline stub resonator discontinuity. In MMIC circuits, the unwanted coupling between circuit-elements is not taken into account generaly in circuit CAD. The present paper gives an investigation in this direction. A comparison with published data as well as with published experimental results is done to verify the present work.

THEORY :

The general structure to be analyzed is a cavity having perfectly conducting walls (fig. 1). It contains three different dielctric layers. Conductor strips can be deposited on each dielectric interface. However, without loosing any generality, only conductor strips deposited on one dielectric interface are considered. The effect of the inclusion of another conductor strips on the other interface can be easily deduced from this study, using a symmetry consideration.

The theory is based on the resolution of integral equations expressing the equality of the diffracted $\vec{E}^d$ and the feeding $\vec{E}^e$ electric fields on a conducting interface. The diffracted electric field can be derived from vector $(\vec{A})$ and scalar (V) potentials which, in turn, can be expressed in terms of electric Green's functions. The obtained integral equation can then be written as :

$$\vec{e}_z \times \left[\int_S \left(j\omega \overline{\overline{G}}_A(\vec{r}_i/\vec{r}).\vec{J}_s(\vec{r}_i) + \nabla G_v(\vec{r}_i/\vec{r}).\rho_s(\vec{r}_i) \right) dS + Z_s \vec{J}_{s_i}(\vec{r}_i) \right] = \vec{e}_z \times \vec{E}^e(\vec{r}_i) \qquad (1)$$

where

$\overline{\overline{G}}_A$ is the dyadic Green function of the vector potential $\vec{A}$,

G_v is the scalar Green function of the vector potential V,

$\vec{J_S}$ and ρ_S are the conductor surface current and charge respectively, Zs is the localized load impedance and E^e the excitation electric field,

$\vec{r}_i$ and $\vec{r}$ denotes the position of the observer and the source, respectively

It is known that the Green functions for open structures have interesting properties, which leads to a considerable reduction in computing time, namely : the translationnal invariance in the xoy plane and rotationnal invariance around the z axis [6]. This is not the case for closed structures. Due to the presence of conducting walls, the potentials created by unit sources in closed structures depend either on the distance between the source and the observer and on its position with respect to the grounded walls. Generalized to an infinity sources forming a general shape of any discontinuity, this last proprerty shows that the characteristic of the discontinuity will be modified when its position in the box will change.

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Firstly, the Green's functions of a closed structure are calculated for both enclosed microstrip line and suspended stripline.Triangular basis functions and pulse test functions are chosen in the developement of the moment method which transforms the integral equations system into a matrix equation one. Two components of strip surface current are taken into account in order to be able to study irregular discontinuities.Then, for extracting the circuit scattering parameters, a matched load is simulated numerically at some last cells at the ends of circuit ports [1] except the one for which the reflection coefficient is calculated.

RESULTS :

Figure 2 shows the variation of the effective relative permittivity of an asymmetric suspended stripline as a function of the strip position with respect to vertical and horizontal walls. For a microstrip (H_1=0), one can see that the effective relative permittivity increases with the increace relative position of the strip with respect to the vertical walls. While, for suspended stripline (H_1>0), the effective relative permittivity decreases as a function of the strip position with respect to the vertical side wall.

The Scattering matrix element S21 for a resonator stub is given in figure 3 for three positions of the resonator with respect to the vertical side wall. A resonance frequency shift is observed when the central conductor is approached to the side vertical wall. Figure 4 shows the results for the example of two stubs mounted in opposite directions with respect to the main line. Our calculated results are compared to those obtained experimentally and to those given using one of commercial CAD programs [7]. The results assure the validity of our analysis and demonstrate the insufficiency of existing commercial CAD tools to take into account interconnection coupling phenomena.

CONCLUSION :

A 2D moment method is used to evaluate parasitic coupling effects in general shielded planar structures. It is shown that the packaging has a considerable effect on the calculated values of the effective permittivity for uniform lines and also of the scattering parameters for planar discontinuities . Moreover, it is shown that the present approach is capable to take into account the interconnection coupling phenomena between discontinuities. The obtained results of the analysis of planar uniform guiding structures, uniaxial and multiaxial discontinuities, including the packging effects prove the suitability of the integral equation technique for solving such complex structures.

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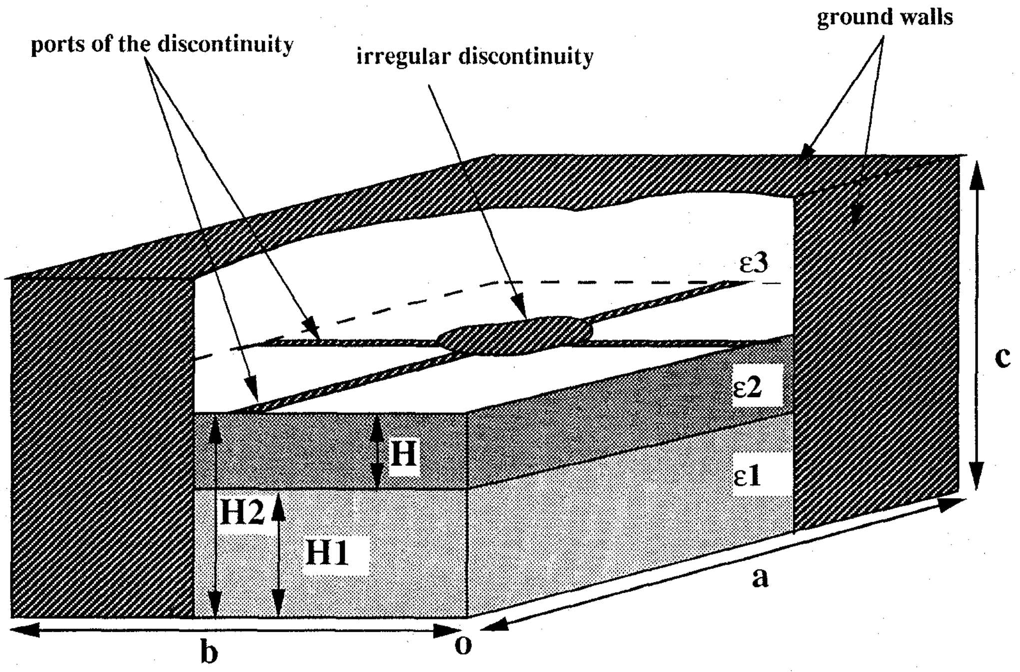

Fig. 1 : A general shielded multilayer microstrip discontinuity

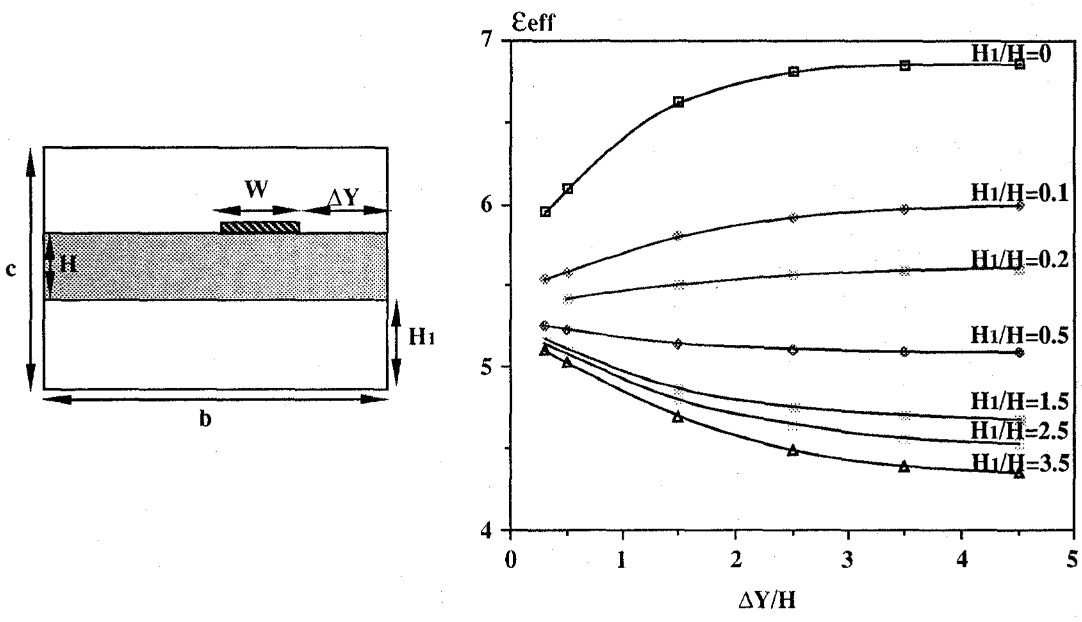

Fig. 2 : Effects of the enclosure on the relative effective permittivity for various substrate positions ($W=H=0.635mm$, $b=6.35mm$, $c=4.445mm$, $\varepsilon r=9.7$).

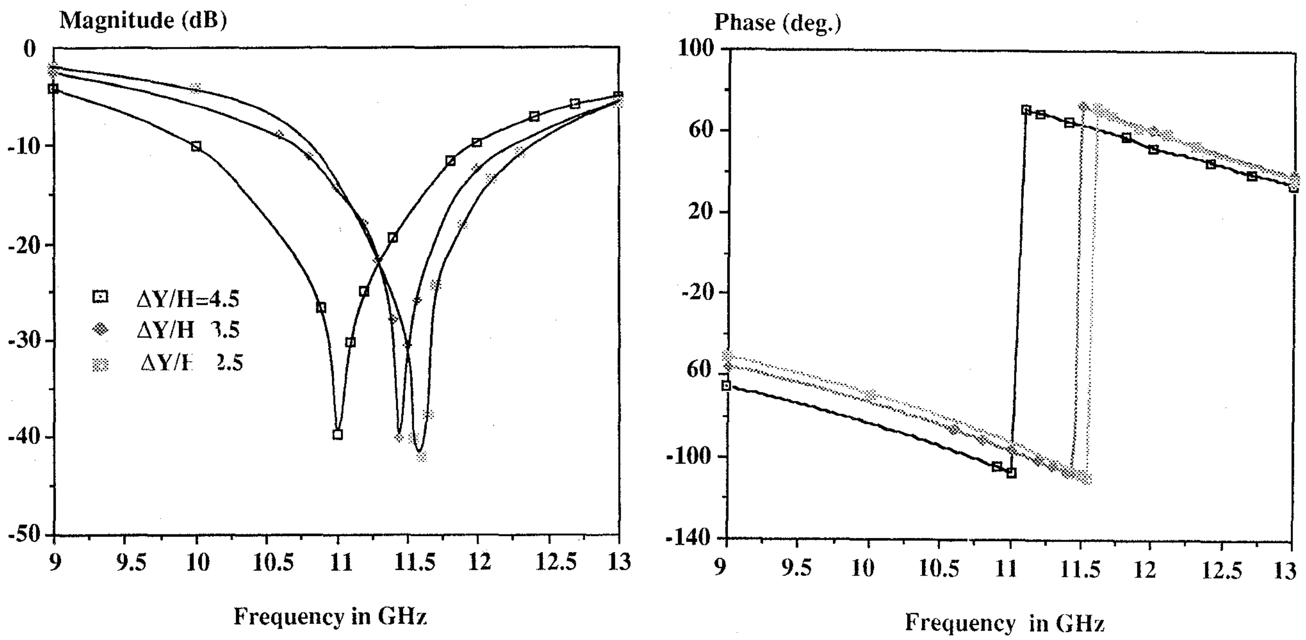

Fig. 3 : Effect of the box coupling on the S21 parameter of a stub discontinuity for three positions of the discontinuity with respect to the vertical side wall of the box (H1=1.65 mm).

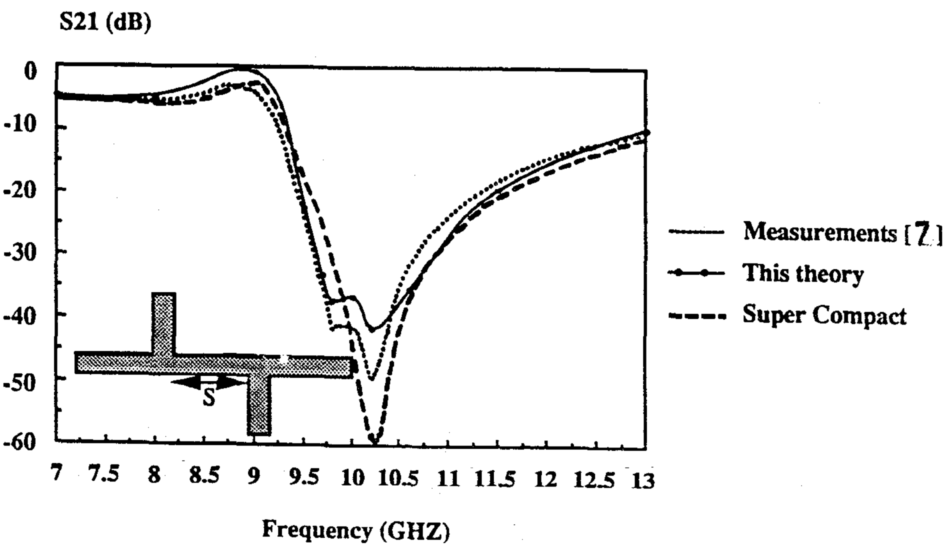

Fig. 4 : Variation of S21 parameter of two opposite stubs as a function of frequency (W=H= 0.127 mm, H1=0 mm, S= 23W, εr=9.8).