1D WCIP and FEM hybridization

Caroline Girard, Nathalie Raveu, Ronan Perrussel, Jia Li, Stéphane Lanteri

1D WCIP and FEM hybridization

C. Girard, N. Raveu, R. Perrussel, J. Li
LAPLACE
CNRS, INPT, UPS, Université de Toulouse
Toulouse, France
cgirard@laplace.univ-tlse.fr

Stéphane Lanteri
Equipe-projet NACHOS
INRIA Sophia Antipolis Méditerranée
Sophia Antipolis, France

Abstract—**The hybridization between two numerical methods, the 1D Wave Concept Iterative Procedure (WCIP) and the 2D Finite Element Method (FEM), is introduced. Preliminary numerical results are also presented.**

Keywords-WCIP; FEM; inhomogeneous planar circuits.

I. INTRODUCTION

The Wave Concept Iterative Procedure (WCIP) is a numerical method dedicated to computations in planar homogeneous multi-layers circuits [1]. Currently, dealing with inhomogeneous dielectric substrate or via-holes is not possible with the WCIP alone. To overpass this difficulty, hybridization with the Transmission Line Matrix method has been achieved in [2] but it is restricted to regular rectangular mesh. Hybridization with the Finite Element Method (FEM) is a way to cope with this issue through unstructured triangular mesh.

II. METHOD

A. 1D WCIP method

The method relies on the behavior of incoming (**B**) and outgoing (**A**) waves upon an interface (Σ) which separates two domains 1 and 2 (Fig. 1). These waves are generated by an incident wave (**B$_{om}$**). The system to be solved is,

$$\begin{cases} A_s = SB_s; A = FMT(A_s), \\ B = \Gamma A + B_{om}; B_s = FMT^{-1}(B), \end{cases} \qquad (1)$$

where S is the scattering operator for boundary conditions on (Σ), Γ is the scattering operator for homogeneous media conditions, FMT is the Fast Modal Transform and FMT^{-1} is its inverse [1].

B. Hybridization principle

Instead of using the WCIP in the two domains, the FEM is implemented in the domain that contains the inhomogeneity (Domain 2 in Fig. 1). The wave A_{y2} (the index 2 refers to domain 2) is the outgoing wave seen from the interface. A_{y2} is a source term in the finite element formulation. The electric field E_{y2} is calculated by FEM with (2).

$$\int_{D2} \nabla E_{y2} \cdot \nabla w dS - k_0^2 \int_{D2} E_{y2} w dS + jk_0 \int_{\Sigma} E_{y2} w dl = \qquad (2)$$
$$2 jk_0 \sqrt{Z_0} \int_{\Sigma} A_{y2} w dl \ ,$$

where w stands for a test function, k_0 is the free space wavenumber and Z_0 the free space impedance.

It enables calculating the incoming wave B_{y2} which becomes an input variable for the WCIP with (3),

$$B_{y2} = \frac{1}{2\sqrt{Z_0}} \left(E_{y2} - \frac{Z_0}{j\omega\mu_0} \frac{\partial E_{y2}}{\partial z} \right) \qquad (3)$$

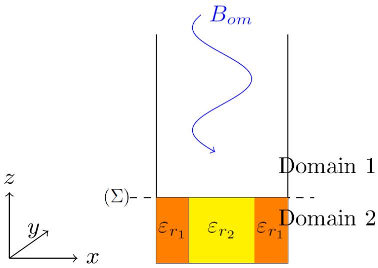

Fig.1: Multi-layers circuit

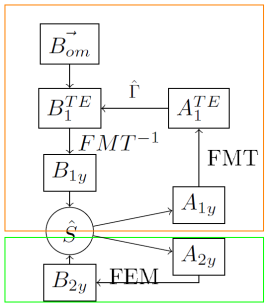

Fig.2: Scheme

The scheme is iterated until required convergence is reached according to Fig. 2.

III. CONCLUSION

Preliminary results over an interface separating two air volumes have been obtained: fields are compared to analytical cases and results are in good agreement with a relative error lower than 0.04%. Other structures have to be tested namely circuits with dielectric substrate change with vertical slope (cf. Fig. 1) or not, and via metallization connecting two metallic surfaces. Algorithm acceleration has also to be considered.

ACKNOWLEDGMENT

The first author is supported by a PhD grant from the Defence Procurement Agency (DGA).

REFERENCES

[1] S. Wane, D.Bajon, H. Baudrand and P.Gamand, "A new full-wave hybrid differential-integral approach for the investigation of multilayer structures including nonuniformly doped diffusions," IEEE MTT., vol. 53, n°1, pp. 200-213, January 2005.

[2] A. Zugari, M. Khalladi, M.Iben Yaich, N.Raveu and H. Baudrand, "New approach: WCIP and FDTLM hybridization," Mediterranean Microwave Symposium (MMS), 2009