MICROWAVE MODULE DESIGN APPLYING A GLOBAL ELECTROMAGNETIC ANALYSIS

F. BODEREAU - D. BAILLARGEAT - S. VERDEYME
M. AUBOURG - P. GUILLON

I.R.C.O.M. - Faculté des Sciences - UMR CNRS 6615
123 Avenue Albert Thomas - 87060 LIMOGES Cédex - France

ABSTRACT

In this paper, an active microwave module containing three MMICs is studied. Our objective is to analyse the MMIC radiation influence on module response. The finite element method is applied to perform a global electromagnetic analysis of the module distributed area. Then, we determine the effect of a metallic boundary placed between MMICs, which permits to decrease the indirect interferences between these circuits.

I - INTRODUCTION

The increase in the operating frequency and in the complexity and also integration density of modern microwave modules and circuits, generates parasitic effects such as indirect interferences between radiant components, metallic enclosure resonances,...

Consequently, a rigorous and global electromagnetic analysis becomes essential to anticipate, limit and cancel these disruptives phenomena, degrading the circuits performances.

We present in this paper, the characterization of a microwave module containing one or several circuits which are themselves constituted of active and passive components. An electomagnetic software, developped in our laboratory, has been used in our study ; it is based on the finite elements method (FEM) applied to solve a field formulation in the frequency domain. The global electromagnetic analysis of a UHF module consist in simulating the distributed part of the structure applying the FEM. However some parts in the analyzed domain, (in our case MMIC circuits) are characterized by lumped element equivalent circuits. Their dimensions are very small in comparison with the wavelength. The so-called "lumped access" [1-2-3], integrated during the electromagnetic simulation, allow the connection of blocs circuits (lumped elements circuits) responses. This lumped access technique ensures the conversion between the electromagnetic field and the current voltage couple, that is to say the interface between the electromagnetic simulator and a classical circuit one.

This method has already been applied to characterize microwave circuits (in which only a part of the circuit components can't be considered localized) [4], or microwave components (to take into account distributed effects in the extrinsic part of an active element) [5].

II - MODULE TOPOLOGY

The microwave device is presented figure 1 and figure 2. It is composed of three MMIC :

- a power MMIC,
- a MMIC for an amplitude phase control,
- a low noise MMIC.

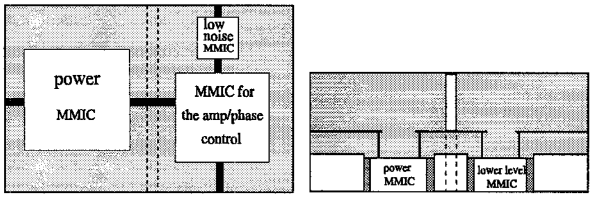

Figure 1 & Figure 2 : Module topology

These MMIC are placed in metallic cavities, and are connected to source RF microstrip lines through metallic holes.

Each MMIC, when it radiates, excites TE and TM modes in the waveguide formed by the surrounding in which it is placed. Because of these waveguides modes radiations in the upper part of the module, indirect coupling phenomena are generated between the circuits. Therefore, the objective of the analysis is to determine the influence of the power MMIC radiation on the both others MMICs responses and then to define the topology of a metallic boundary placed to split the both low level MMIC from the power circuit influence one.

III - METHODOLODY

We first extract the MMIC from the metallic casings and open these ones, in their inferior plane. A modal decomposition is performed in the access plane of these so formed waveguides on some evanescent or propagating TE_i and TM_j modes. (a_{1i}, a_{1j}) are the magnitude of the TE_i and TM_j radiant sources placed at the power MMIC level. We determine then the radiated fields levels in low level MMIC sites (b_{2i}, b_{2j}).

A structure section which describes this technique is presented figure 3. The direct meshing of the whole distributed part of the module generates important calculation times. It is in this case more efficient to apply a segmentation method for the electromagnetic analysis.

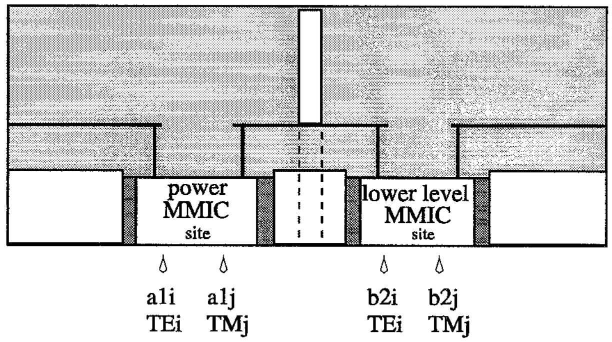

Fig 3 : Methodology

We divide the structure in the three parts described in figure 4.

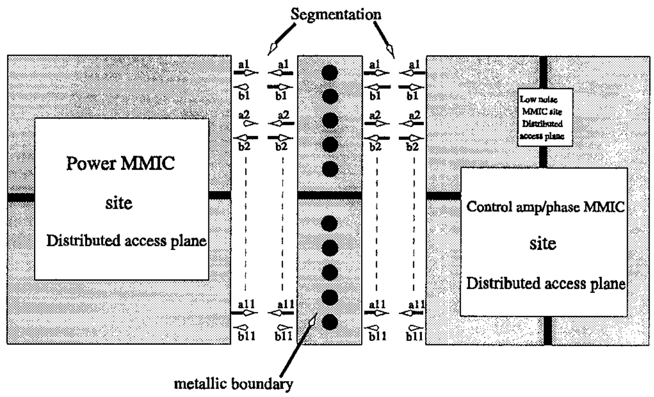

Fig 4 : Segmentation method

The first part contains the power MMIC site (the FEM mesh is presented figure 5), the second part contains the metallic boundary (the FEM mesh is presented figure 6) and the third the lower level MMICs sites (the FEM mesh is presented figure 7),. We can note the geometrical symetries of the both first structures. Taking into account these symetries we reduce significantly the calculation time required for the module analysis.

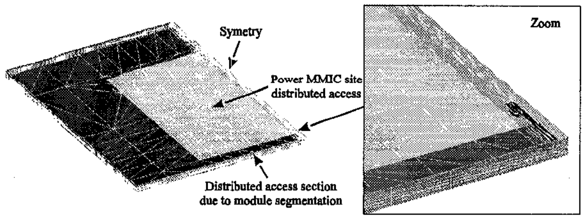

Fig 5 : Meshing of the sub-structure containing the power MMIC's site

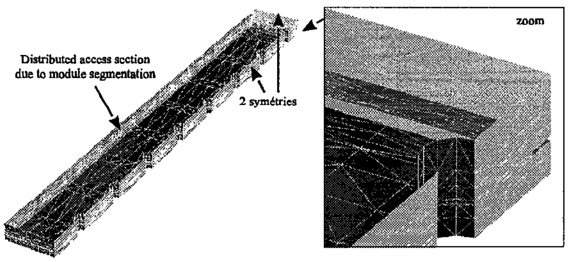

Fig 6 : Meshing of the sub-structure containing the boundary between MMICs

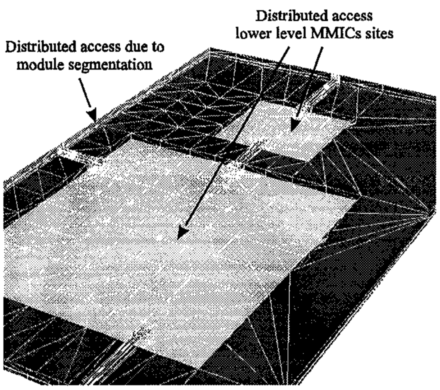

Fig 7 : Meshing of the sub-structure containing the lower level MMICs sites

Each sub structure is separatly meshed and simulated by the FEM software. In each interface plane between the three sub sections (figure 4), a modal decomposition is performed on the TEM propagating mode and the $TE_{n,m}/TM_{n,m}$ modes of the guide formed by the module sections.

Figure 8 shows the connection of the three generalized [S] parameters boxes, coming from the simulation with the FEM, of the three sub-structures. The identical modes in the face to face accesses are connected together. A program permits to put these modes in phase and to secure a continuity of electromagnetic fields. Now the interest becomes to determinate the coupling level between voltage/current waves in the differents MMIC sites.

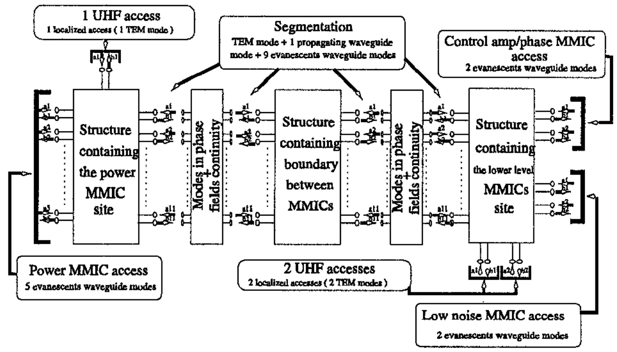

Fig 8 : [S] parameters boxes connection resulting from the segmentation method

IV - RESULTS

The results presented in figure 9 (resp 10), show the couplings between the first evanescent mode of the waveguide formed by the power MMIC site, with the two first modes considered in the lower noise MMIC (resp amplitude/phase control MMIC) site. Five boundary configurations have been considered:

- an interface without metallic wall,
- a 100 µm thick continuous metallic wall,
- different metallic boundaries composed of metallic holes. The diameter is equal to 100 µm and the distances 200 µm, 400 µm, 600 µm between the holes have been considered.

The wide of the metallic opening or spacing between two metallic holes around the microstrip line, have been chosen to not disturb the TEM mode propagation along this line.

The curves (on figures 9 and 10) show the advantage of placing a metallic boundary between MMIC. Indeed the coupling between waveguide modes generated by the MMIC radiations are reduced very significantly.

The four metallic barrier configurations give identical results.

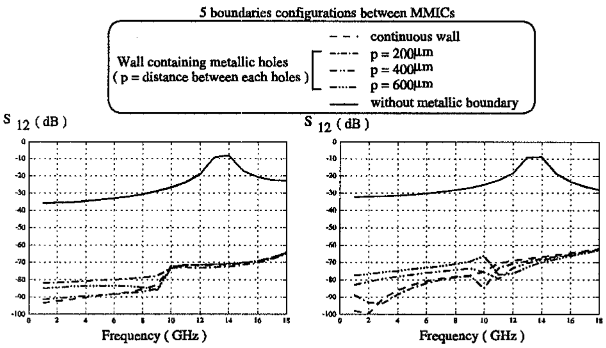

Fig 9 : Coupling between the first evanescent mode of the power MMIC access with the both evanescent modes of the low noise MMIC access.

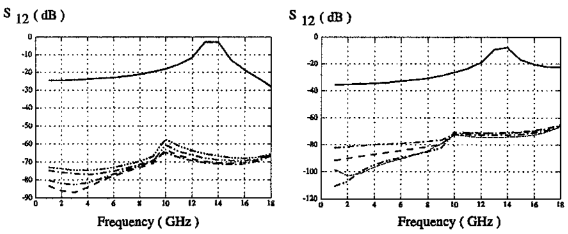

fig 10 : coupling between the first evanescent mode of the power MMIC access with the both evanescent modes of the control amp/phase MMIC access

V - CONCLUSION

A 3 dimensional electromagnetic FEM analysis has allowed to show that the insertions of a metallic boundary between MMIC, have clearly decreased the harmful effect of the power MMIC radiation face to the lower level MMICs.

The global response of the active module can be obtained by insertion of lumped accesses under the RF connection plots. After the FEM simulation of the distributed structure, we have only to connect by means of a circuit software, the response of each MMIC to the corresponding lumped access. An experimental validation of our computations is performed now. Results will be presented in a final paper if the study is accepted to be presented during the MTT.

ACKNOWLEDGMENT

This work is supported by a french army (DRET) contract and is performed in collaboration with Thomson and LETI Society. The authors would like to thank these organisms.

REFERENCES

[1] **K. GUILLOUARD, M.F. WONG, V. FOUAD-HANNA, J. CITERNE**
"A new global finite element analysis of microwave circuits including lumped elements"
IEEE MTT-S Digest, June 17-21, 1996, San Francisco (USA), vol.1, pp.355-359

[2] **J. KUNISH, I. WOLFF**
"The compression approach : a new technique for the analysis of distributed circuits containing non linear elements"
IEEE MTT-S Workshop WSK : "CAD of non linear microwave circuits using field theoretical methods", June 1992, pp.15-31

[3] **S. VERDEYME, V. MADRANGEAS, D. CROS, M. AUBOURG, P. GUILLON**
"Design of microwave devices using the finite element method"
Workshop on Global Electromagnetic Analysis of Microwave Circuits, IEEE MTT, San Francisco, USA, June

[4] **D. BAILLARGEAT, E. LARIQUE, S. VERDEYME, M. AUBOURG, R. SOMMET, P. GUILLON**
"Coupled localized and distributed elements analysis appliyng an electromagnetic software in the frequency domain"
IEEE MTT-S Digest, June 8-13, 1997, Denver, Vol.2, pp.1021-1024

0-7803-4471-5/98/$10.00 (c) 1998 IEEE