Analysis of multilayer amplifier structure by an efficient iterative technique

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Abstract—A new compact microwave amplifier structure using an iterative technique based on the wave concept (WCIP) is presented. This new multilayer structure is composed of five planar interfaces with microstrip lines. The technique used to model this structure provides a mixed resolution in modal and spatial domain taking the best advantage of each resolution domain and lower computation time. The purpose of this work is to demonstrate that a near field amplification technique is possible and the WCIP is suitable to electromagnetic analysis of this kind of structure.

Index Terms—Microwave amplifier, Iterative methods, Electromagnetic analysis.

I. INTRODUCTION

The manufacturing of miniaturized hybrid microwave integrated circuits (MHMICs) is performed either by using the multilayer LTCC or HTCC (low or high temperature cofired ceramic) technology [1]. The use of multilayer circuits makes microwaves circuits more compact and the design more flexible [2]. For applications in the millimeter-length bands, new methods for the conception of these circuits have been developed, and others perfected, in order to meet requirements such as cost, performance and complexity. These methods allow the integration of different functions on the different planar surfaces among the dielectric layers on which the active and passive elements are deposited using several techniques. This article presents an efficient technique based on the Wave Concept Iterative Procedure (WCIP) for solving continuity conditions in terms of waves rather than in terms of tangential electric and magnetic field to analyze a compact microwave amplifier structure. This method is not conditioned by the complexity of the circuit design and was proved to be particularly interesting for planar circuit [3].

In the work reported herein the analysis and simulation of a structure with five interfaces were carried out as represented in Fig. 1.

Fig. 1. Block diagram of the amplifier structure

Section II provides the formulation used with the WCIP. Simulations and results are presented in section III. Finally, conclusions are included in section IV.
The first step of the method is the electromagnetic analysis of the passive structure substituting the active element by an auxiliary feed as shown in Fig. 3. (a).

Fig. 3. (a) Passive structure analysis (b) Active structure analysis

The admittance matrix $Y_{ij}$ of the structure is determined using the WCIP. The second step consists in substituting the auxiliary feed by the electrical representation of the active element as illustrated in Fig. 3. (b), where $Z_d$ represents the impedance of a diode. Considering this active element as negative impedance:

$$ J_1 = \frac{-E_1}{Z_d} \tag{5} $$

As a result, a new admittance matrix is calculated and the three-port circuit becomes a two-port circuit. From this admittance matrix of the amplifier structure, the coefficients of the equivalent scattering matrix are given as:

$$ S_{11} = \frac{(1 - Z_d Y_{11\text{Ampl}})(1 - Z_d Y_{22\text{Ampl}}) + Z_c^2 Y_{12\text{Ampl}} Y_{21\text{Ampl}}}{(1 + Z_d Y_{11\text{Ampl}})(1 - Z_d Y_{22\text{Ampl}}) - Z_c^2 Y_{12\text{Ampl}} Y_{21\text{Ampl}}} \tag{6} $$

$$ S_{11} = \frac{-2 Z_c Y_{21\text{Ampl}}}{(1 + Z_d Y_{11\text{Ampl}})(1 - Z_d Y_{22\text{Ampl}}) - Z_c^2 Y_{12\text{Ampl}} Y_{21\text{Ampl}}} \tag{7} $$

where $Z_c$ is a 50Ω characteristic impedance.

Finally, it is possible to express the boundary conditions in terms of waves on each cell of the structure under study.

### III. Simulation Results

In order to present and evaluate the performance of the proposed tools, a simulation of the amplifier structure was performed. Fig. 4 shows the multilayer structure with the physical interfaces used with the auxiliary feed method.

Fig. 4. 3-D view of the structure with auxiliary feed

On the first interface, the microstrip feed line has width of 2mm and length of 18mm. On the second interface the L-resonator has width of 4mm and length of 20mm. On the third interface, the microstrip line has the same dimensions as the first interface. Expressing the polarizers directly into the modal domain avoids the discretization in the spatial domain. Therefore, a time computational of 30% associated with these operations is released. The waveguide is 32mm wide and 32mm long, $\varepsilon_{r1} = \varepsilon_{r2} = \varepsilon_{r3} = 2.2$, $\varepsilon_{r4} = 1$ and $l_1 = l_2 = l_3 = 0.65$mm. A simulation of the proposed amplifier structure was conducted varying the negative impedance of the diode from -120 Ω to -60 Ω at a frequency of 5.6GHz. As seen in Fig.5, a gain of 13.4dB is obtained for negative impedance $Z_d$ of 80Ω.

IV. Conclusion

In this paper, an implementation of the WCIP for a multilayer amplifier structure is presented. The obtained results show that the method herein formulated and computationally implemented is suitable to electromagnetic analysis. A very good result of 13.4 dB is obtained with a simple negative impedance model. The next step of this work is to substitute this impedance by a transistor model using the WCIP and the auxiliary feed method.

### References


