International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IJIEMR Transactions, online available on 6th Jan 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-01

DOI: 10.48047/IJIEMR/V10/I01/04

Title: **STUDY OF THE MOVEMENT OF ELECTROMAGNETIC WAVES IN INTEGRATED CIRCUITS**

Volume 10, Issue 01, Pages: 20-25

Paper Authors

AMRI Houda, ZAABAT Mourad

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

STUDY OF THE MOVEMENT OF ELECTROMAGNETIC WAVES IN INTEGRATED CIRCUITS

[1]AMRI Houda, [2]ZAABAT Mourad
[1]laboratory of physics matter and radiation LPMR. Department of material sciences, Faculty of Sciences and Technologies University of Mohamed Cherif Messaadia Souk Ahras, Algeria
amrihouda@gmail.com
[2]Laboratory of Active Components and Materials University of Oum El Bouaghi, Oum El Bouaghi 04000, Algeria

Abstract-The advent of the integrated circuit revolutionized the electronics industry and paved the way for devices such as mobile phones, computers, CD players, televisions, and many appliances found around the home. In addition, the spread of the chips helped to bring advanced electronic devices to all parts of the world. For this reason, we have studied the transmission or the movement of electromagnetic waves to determine some proprieties of the integrated circuit
Keywords- Electromagnetic waves, iterative method, integrated circuit, FMT, scattering operator, transmission, scattering,

I. INTRODUCTION

Integrated circuit (IC), also called microelectronic circuit, microchip, or chip, an assembly of electronic components, fabricated as a single unit, in which miniaturized active devices (e.g., transistors and diodes) and passive devices (e.g., capacitors and resistors) and their interconnections are built up on a thin substrate of semiconductor material (typically silicon). The resulting circuit is thus a small monolithic “chip,” which may be as small as a few square centimetres or only a few square millimetres. The individual circuit components are generally microscopic in size.

The champion of microelectronics (the integrated circuit) is born at the turn of the century, electronics have continued to develop more and more rapidly over the past twenty years. It was the imperatives of defense which, during the Second World War, definitively imposed on it two of its fundamental criteria: a great operational safety, essential to the instruments on board of the planes and are written off, are rapid external signals. Since 1945, the development of telecommunications, the arms race and, later, the space competition have demanded three additional qualities of electronic systems: reliability, that is to say correct operation during a large number of increasing periods. , weight and volume reduction and low energy consumption. For their part, users of calculators demanded ever faster machines. The research carried out to obtain components and systems meeting all these criteria - reliability,

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

miniaturization, low consumption and in short, resulted in the manufacture of new microstructures, the integrated circuits.

An application-specific IC (ASIC) can be either a digital or an analog circuit. As their name implies, ASICs are not reconfigurable; they perform only one specific function. For example, a speed controller IC for a remote control car is hard-wired to do one job and could never become a microprocessor. An ASIC does not contain any ability to follow alternate instructions.

II. THE WAVE CONCEPT ITERATIVE PROCESS

Consider a surface separating two dielectric media with permittivity's $\varepsilon 1$ and $\varepsilon 2$ assumed to be perfect (without losses). The surface can include different domains, namely the metallic domain, the dielectric domain and the domain of the source which will supply the circuit. The structure is enclosed in a box with electric walls. Figure 1 shows a microstrip structure, characterized by the zero-thickness Ω interface, and placed in a metal case. The Ω interface, on which the microwave circuit is printed, separates two media 1 and 2 characterized respectively by $\varepsilon 1;1$ and $\varepsilon 2;\mu 2$ [1]

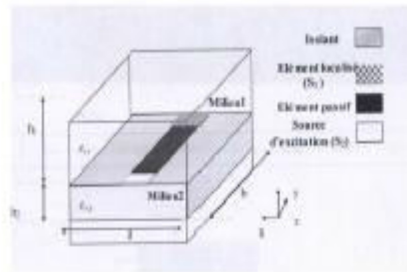


Figure 1. The planar structure

The wave concept iterative process is introduced by writing the tangential electric field E and surface tangential current density J in terms of incident and reflected waves

$$A_i = \frac{1}{2\sqrt{Z_{0i}}}(E_i + Z_{0i}J_i) \qquad E_i = Z_{0i}(A_i + B_i)$$
$$B_i = \frac{1}{2\sqrt{Z_{0i}}}(E_i - Z_{0i}J_i) \Rightarrow J_i = Z_{0i}(A_i - B_i) \quad (1)$$

Where $Z_{0i} = \sqrt{\frac{\mu_0}{\varepsilon_0 \varepsilon_i}}$ characteristic impedance of region i [2]

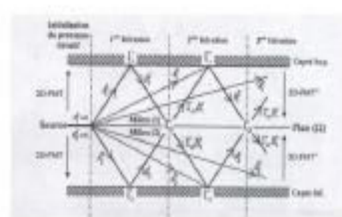


Figure 2. The WCIP principle

The balance of waves A and B between spatial and spectral domains is ensured by a Fast Modal Transform FMT. The principal equations of this process has defined by

$$A = \hat{S}.B + A_0 \qquad (2)$$
$$B = \hat{\Gamma}.A$$

Where $\hat{\Gamma}$ is the reflecion operator wich takes into account the environment's reaction in spectral domain

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

$\hat{S}$ is the scattering operator witch takes into account the boundary conditions in the spatial domain

$\mathbf{A_0}$ exciting source wave

A. The reflection operator $\hat{\Gamma}$

This operator is defined by

$$\hat{\Gamma} = \frac{1-Z_{0i}Y_{mn}^{\alpha}}{1+Z_{0i}Y_{mn}^{\alpha}} \qquad (3)$$

where α indique TM or TE mode and Y_{mn}^{α} is the admittance matrix

- Open waveguide

$$Y_{m,n}^{TE} = \frac{\gamma_{m,n}(\varepsilon_{ri})}{j.\omega\mu_0} \; ; \; Y_{m,n}^{TM} = \frac{j.\omega\varepsilon_0\varepsilon_{ri}}{\gamma_{m,n}(\varepsilon_{ri})} \qquad (4)$$

- Court circuit

$$Y_{m,n}^{\alpha,k} = Y_{m,n}^{\alpha}\left(\varepsilon_{ri}\coth\left(\gamma_{m,n}(\varepsilon_{ri}).h\right)\right) \qquad (5)$$

B. The scattering operator $\hat{S}$

The space scattering operator $\hat{S}$ is deduced from the equivalent circuit in each subdomain of surface

. conductor: $E_1 = E_2$

$$\hat{S}_{\Omega c} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$$

. dielectric: $\begin{matrix} E_1 = E_2 \neq 0 \\ J_1 = J_2 = 0 \end{matrix}$

$$\hat{S}_{\Omega d} = \begin{bmatrix} \frac{Z_{02}-Z_{01}}{Z_{01}+Z_{02}} & \frac{2\sqrt{Z_{01}Z_{02}}}{Z_0-Z_{01}} \\ \frac{2\sqrt{Z_{01}Z_{02}}}{Z_0-Z_{01}} & \frac{Z_{02}-Z_{01}}{Z_{01}+Z_{02}} \end{bmatrix}$$

.source: $E = E_0 - Z_0 J$

$$\hat{S}_{\Omega s} = \begin{bmatrix} \frac{Z_{02}Z_{01}+Z_0(Z_{01}-Z_{02})}{Z_{01}Z_{02}+Z_0(Z_{01}+Z_{02})} & \frac{2\sqrt{Z_{02}Z_{01}}}{Z_{01}Z_{02}+Z_0(Z_{01}+Z_{02})} \\ \frac{2\sqrt{Z_{02}Z_{01}}}{Z_{01}Z_{02}+Z_0(Z_{01}+Z_{02})} & \frac{Z_{02}Z_{01}+Z_0(Z_{01}-Z_{02})}{Z_{01}Z_{02}+Z_0(Z_{01}+Z_{02})} \end{bmatrix}$$

Finally $\hat{S}$ is expressed as follows:

$$\hat{S} = \hat{S}_{\Omega c} * \hat{H}_m + \hat{S}_{\Omega d} * \hat{H}_i + \hat{S}_{\Omega s} * \hat{H}_s \qquad (6)$$

[3]

III. APPLICATIONS AND RESULTS

To validate the presented theory, we propose to study two structures

A. The spiral inductor

The analysis structure is composed of rectangular waveguide, his dimensions are a = 15mm, b = 6mm, h = 0.2mm and the substrate characteristics are h = 0.02mm and εr = 12.9 The discontinuity plane is divided into cells and includes four subdomains isolated, metal, source and spiral inductor

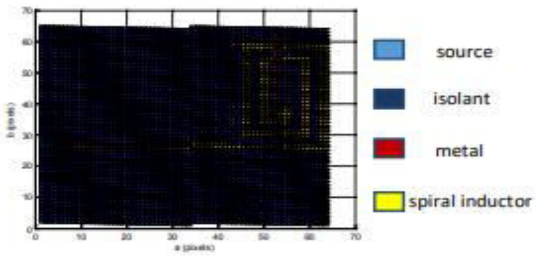


Figure 3. The discontinuity plan

The boundary conditions have confirmed by the tangential electric fields and the current density figured in -Figure 4- and –Figure 5-

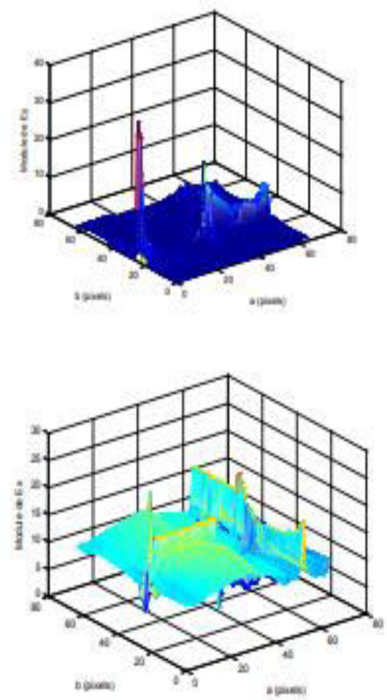


Figure 4. Component of electric fields in x ,y direction

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

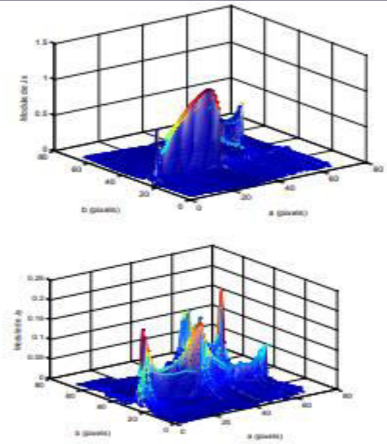
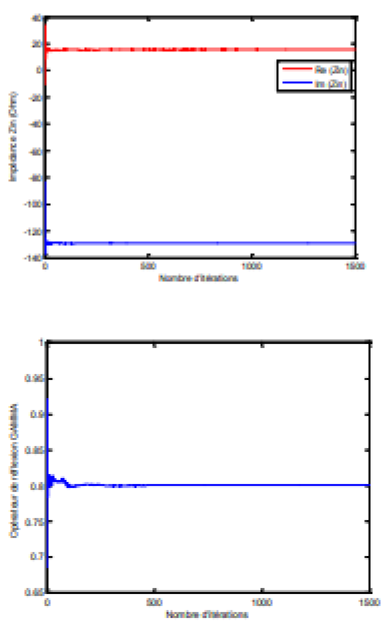


Figure 5 . Component of current density in x ,y direction

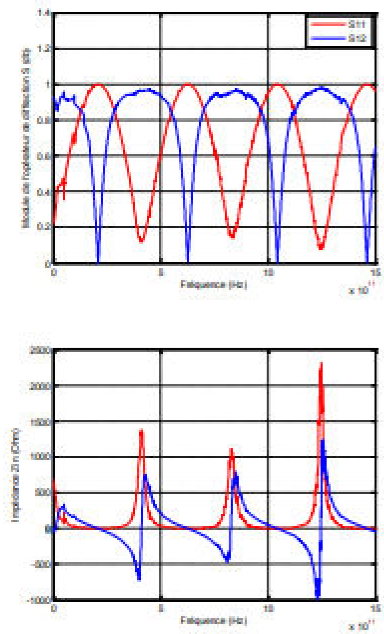
For the convergence of the numerical method calculation, the reflected operator and the source impedance Zin have examined at first as a number of functions as shown in figure 6 (a.b), is clear that the convergence is achieved for 129 iterations from reflection operator and 51 functions, 88 functions from real and imaginary parts of Zin



-a-

-b-

Figure 6. The convergence study against the number of functions -a- reflection operator –b- source impedance Zin The variation of the scattering operator S as a function frequency is ploted in figure 7, these results shows that the first resonance frequency obtained y the spiral inductor is $fr = 4.09GHz$; then this resonance has periodic y $n * fr$ where $n \in N$



-a-

-b-

Figure 7. Simulation study against the frequency –a- the $\hat{S}$ modules –b- the Zin impedance

B. The MESFET transistor

in this section we will analyze an active element (MESFET transistor) under the same previous conditions the results obtained are presented in the figures below

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

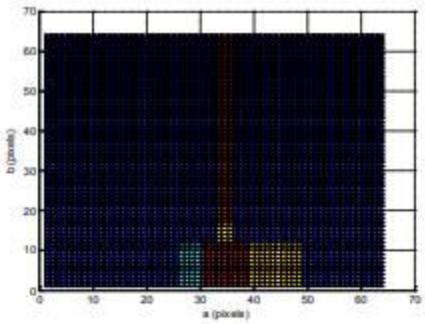
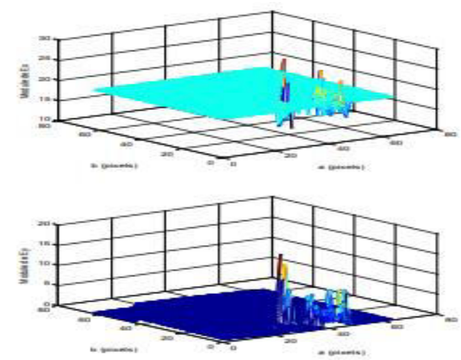


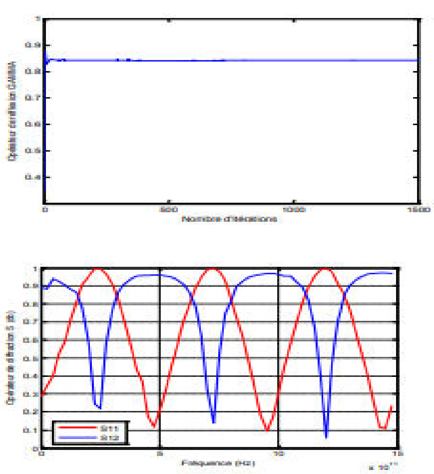
Figure 8. The surface plan of MESFET transistor



a-

-b

Figure 9. Component of electric fields in x ,y direction



-a-

-b-

Figure10. the convergence of the WCIP and the simulation study

when MESFET is an active element, the power of electromagnetic waves is increased in relation to the spiral inductor and that is what represented in the curve of the variation of reflection and transmission coefficients in relation to the frequency. according to the curve the maximum values of the coefficient S11 is varied in each resonance the more the resonance frequencies are different than the spiral inductor

C. Integrated circuit In this section we will simulate the integrated circuit shown in figure 11 to determine the characteristics of this circuit The subdomains of this structure are: insolentspiral inductor- condensator-resistor- MESFETmetal- source

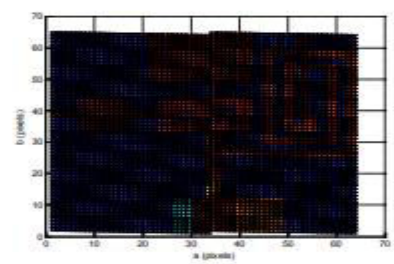
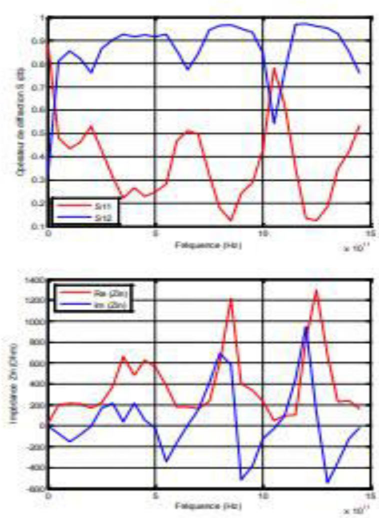


Figure 11. The surface plan of an integrated circuit



-a-

-b-

Figure 12. Simulation study against the frequency –a- the $\hat{S}$ modules –b- the Zin impedance

The module of scattering operator S gives that the resonance frequency is $fr = 8.51 * 10^3 GHz$ where $Zin = 1211 Ohm$ and Bandwidth is $Bp = 10^3 GHz$

These values can be noted that we have an quality factor $Q = 8.51$ so our oscillation is pseudoperiodic with a period $T = 6.91ms$ The Q Factor presents that the dissipated power is very small in this transport of waves in the cavity D.

CONCLUSION

This work was to carry out a study of the transport of electromagnetic waves in integrated circuits based on gallium arsenide. Even though this material had precedence over silicon, it had almost disappeared from the industry. Currently the intrinsic advantages of this material in terms of switching speed, but also its performance superior to that of silicon in the field of opto-electronics, give it a new lease of life in the field of high frequencies and we see the reappearance of a manufacturing industrial based on this technology.

REFERENCE

[1] Noemen Ammar Henri Baudrand, ''The wave concept iterative process (WCIP) method for electrical circuit network with triangular and hexagonal topology'', International journal of circuit theory and applications Volume47, Issue8. 03 June 2019

[2] Henri Baudrand Mohammed Titaouine Nathalie Raveu. ''WCIP Convergence'' The Wave Concept in Electromagnetism and Circuits: Theory and Applications CHAPTER 5. , 2016,

[3] M.Glaoui, A. Hajlaoui, H. Zairi, H.Trabelsi and h.baudrand, , ''modelling of non-linear element using an extended iterative method'', .Microwave and optical technology letters / vol. 49,no. 1. Januray 2007