Electric Current and Voltage Behaviour for a Perturbed Capacitor Lattice with Planar Triangular Design

Noemen Ammar[1]

[1] Utara Universiti Malaysia

Received: 14 December 2018 Accepted: 2 January 2019 Published: 15 January 2019

Abstract

The wave concept iterative process (WCIP) method is introduced in the goal to study the electric voltage and current distribution for a planar capacitor circuit with equilateral triangular architecture, excited by a vertical lumped source. The grid is governed by three planar directional vectors phase shifted the one to the other to 60 degree. The formulation employ the definition of the auxiliary sources for modelling the electrical components of the circuit (resistor and capacitor). Simulation results consider the current distribution on an RC circuit network with equilateral triangular lattice for both regular and perturbed design.

Index terms— capacitor circuit, equilateral triangular lattice, wcip method, current and voltage distribution

1 INTRODUCTION

ecently, interconnect circuit attract increasing attracting in a wide area of scientist researchers such as circuit theory design, microwave application, integrated circuit and physical model. The circuit networks analysis and design have been addressed by many research's regarding several architectures with finite or infinite size [1][2][3][4]. Many competitive methods have been developed to improving the design and modelling of the several lattice. Among them we cited, the Green function lattice [5], the Laplacian matrix [6] and the Recursion Transform method [7].

However, despite the accuracy and efficiency of these methods, there are limited to the analysis of the equivalent resistance or impedance for homogenous circuits excited an exterior source.

Latterly, a new approach of the Wave Concept Iterative Process method (WCIP) [8] is for computing the effective impedance and the current distribution of an RLC electrical circuit with triangular or hexagonal lattice. accurately model continuous mediums if the cell's length is much smaller than the lattice.

The main keys of the proposed method was summarised as follows: (1) the incoming and outgoing wave's concept definition from the electrical entities (voltage and current).

(2) The introduction of the auxiliary sources techniques instead of the circuit components. (3) the use of the Fourier transforms appropriate to hexagonal and triangular lattice named HFFT (hexagonal fast Fourier Transform) and the resolution of the alternative (spectral-spatial) equations by an iterative process.

Therefore, the mathematical formulation is developed into two definition domains; a spectraldomain in which periodicity and coupling between components of the circuit was defined and a spatial one describing the topology and values of network elements, and imposing the continuities conditions (Kirchhoff's laws). The above relations represent a recursive system, which is resolved by an iterative process; the transition between one domain to another is guaranteed by the HFFT and its inverse.

In the first part of this paper, we develop the mathematical formalism describing the new WCIP method approach. In the second part, we show the design of the proposed circuit results, such as the spatial variation of the electric field inside the resonator and the frequency response of the transmission coefficient.

2 II.

3 THEORETICAL FORMULATION a) Waves definition

The WCIP principle is described in many papers; it is founded on the introduction of the incident (A) and reflected (B) waves tangential to each edge of the network. These waves are defined from the voltage and the current by the following equation:( ) ( ) ? ? ? ? ? ? ? ? ? = + = I Z V Z B I Z V Z A 0 0 0 0 1 1 (1)

Where, 0 Z is an arbitrary chosen impedance. The WCIP method is successfully used, near two decades, in the analysis of planar micro strip microwave circuits [9], [10] and it is demonstrating its power for solving the radiation and scattering electromagnetic problems [11][12][13]. The method is also reformulated to analyze quasi-periodic lumped circuits with rectangular grid [14].These periodic lumped circuits can be considered as good equivalent representations to

The electric current (I) and the voltage (V) can be calculated as follows (**??**):( ) ( ) ? ? ? ? ? ? = + = B A Z I B A Z V 0 0 1 (2)

4 b) Spectral-domain analysis

This domain characterizes the physical relations (periodicity and Kirchhoff laws) established between the electrical components and written in waves term.

Fig. 1 shows an electrical circuit network, the electrical schema considers a capacitor connected to a resistor and distributed according to an equilateral triangular grid. The circuit is excited by a lumped source located in the center (n=0, m=0) at a vertical edge.

5 With

The unit cell of the studied network is represented by the Fig. 2; it considers three horizontal branches connected to a vertical one at the nodes. The The subscript (*) denote the conjugate of a complex number. ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? Î?" = ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? m n A m n A m n A m n A m n B m n B m n B m n B

6 c) Spatial domain analysis

In the spatial domain, every auxiliary source replace by its corresponding impedance (capacitor, inductor or resistor), then the spatial reflexion operator is given by1 0 0))((? + ? = Z Z Z Z S (**8**)

For the open and shorted circuit, the spatial reflexion operator is given by? ? ?? = circuit open the For circuit short the For S 1 1 (**9**)

In considering the excitation source, the reflected waves are related to the incidents ones by the following relationship0 A SB A + = (**10**)

With 0 A represents the feeding source in wave term.

7 d) Iterative process

Collecting (**??**) and (10), the iterative process is governed by a set of two equations describing, the boundaries condition (Kirchhoff's laws) in the spatialdomain and the periodicity laws in the spectral-domain. The Hexagonal Fast Fourier Transform (HFFT) and its inverse (HFFT) -1 , ensure the transition between the two domains (Fig. 3) [8]. Electrical quantities: current and

8 NUMERICAL RESULTS

The above formulation is employed for calculated the electrical current components on the horizontal edges of the lattice and the potential difference between the nodes and ground in a first step, then the method is also used to investigating the socalled perturbed lattice.

In the numerical example, the total cells number are fixed to N= 100 and M=116, and we take C=2.3pF and R=0.4 ?. The circuit is excited by a voltage source E 0 = 1V, the source is located at the middle of the circuit in (N =0, M =0). **??** shows the vertical voltage propagation; we note that the dispersion is considerable in the proximity of the feeding source.

9 Fig. 5: Vertical voltage repartition

In the next, we analysis the so called perturbed lattice. A perturbed lattice is defined, in many types of research that interested in computing the equivalent resistance or impedance between two arbitrary nodes, by the network wherein we remove one or two bonds from the regular circuit. Herein, we extend this description and we define a perturbed architecture by the lattice that we remove one or many arbitrary part. 9) and (10) demonstrates that the propagation becomes more degenerate when the surfaces and number of the removed bans increases. It is worth noting that the problems of the electrical perturbed circuits become more interesting for several physical difficulties analysis, notably for in the modelling of semiconductors with electrical default.

IV.

10 CONCLUSION

In this paper, a full-wave concept was formulated to investigate an RC circuit with triangular lattice. The method is defined in two definition domains: a spectral-domain describing the periodicity laws and a spatial-domain in the design of the circuit is defined and the Kirchhoff's laws are imposed. The auxiliary sources was introduced for characterizing the potential difference across each electrical element.

In numerical results, the electrical current and vertical potential difference distribution are visualized for a planar capacitor-resistor circuit with triangular architecture. The perturbed RC circuit is also defined and investigated, we observe a deformation of the electrical current and voltage. [1]

1 $\vec{e}_{\beta}$

Figure 1: Fig. 1 :

2 $\vec{e}_{\gamma} = \vec{e}_{\beta} - \vec{e}_{\alpha}$

Figure 2: Fig. 2 :

3 I_{α}

Figure 3: Fig. 3 :

44 I_{β}

Figure 4: Fig. 4 Fig. 4 :

67 E_{α}

Figure 5: Fig. 6 :FFig. 7 :

8910 E_{β}

Figure 6: Fig. 8 :Fig. 9 :Fig. 10 :

[Global Journal of Researches in Engineering] , *Global Journal of Researches in Engineering*

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