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Wave Iterative Computation for Fractal Microstrip Patch Antenna

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Abstract

This paper presents an analysis of fractal microstrip patch antenna using new wave iterative computation (WIC) that is a full electromagnetic wave analysis. The wave iterative simulation based on wave propagation and iterative method is created on graphical user interface (GUI) of MATLAB software. The proposed fractal microstrip patch antenna is simulated by developed simulation program and measurement using network analyzer. The analyzed result using wave iterative computation was successfully in comparing with results of measurement and classical simulation tools.

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Keywords: Wave Iterative Computation, Fractal Microstrip Patch Antenna, Simulation tool;

1. Introduction

The microstrip patch antenna design is popular for the researcher because it is a low cost material, lightweight and also easy to fabricate [1]. The possibility of developing antenna analysis has been improved due to use of fractal concept [2]. In the design and analysis of antennas is being used by numerical method, such as the Finite Differential Time Domain (FDTD)[3], Method of Moments (MOM). More ten years ago, the efficiency computation of Wave Iterative Computation (WIC) has been developed and applied by using the wave concept iterative procedure (WCIP) [4]. Thus, in this paper, we present and develop the Wave Iterative Computation (WIC) to apply with the fractal microstrip patch antenna structure.

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2. Wave Iterative Computation [4]

Wave conception, the principle of Wave Iterative Computation (WIC) is calculating the evolution of incident, reflected and transmitted waves within the metallic box structure, as depicted in Fig.1.

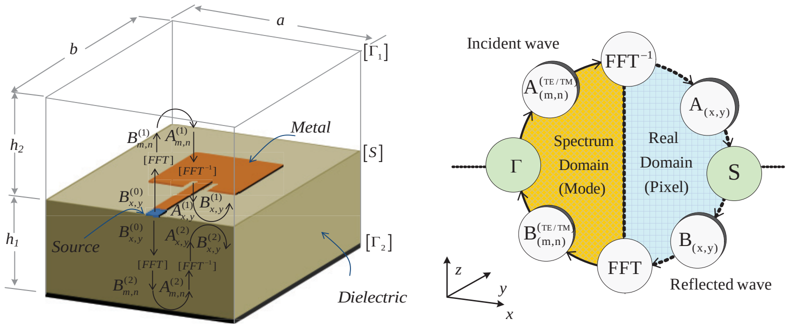

Fig. 1. Patch antenna within metallic box and the wave iterative computation process.

Considering in Fig.1, the incident waves $\vec{A}_i$ and reflected waves $\vec{B}_i$ are defined in equation (1) where the layer i=1, 2 of box structure,

$$\vec{A}_i = \frac{1}{2\sqrt{Z_{oi}}}(\vec{E}_i + Z_{oi}\vec{J}_i), \quad \vec{B}_i = \frac{1}{2\sqrt{Z_{oi}}}(\vec{E}_i - Z_{oi}\vec{J}_i). \tag{1}$$

The equations of electric field $\vec{E}_i$ and current density $\vec{J}_i$ are derived from the following equations ,

$$\vec{E}_i = \sqrt{Z_{0i}}\left(\vec{A}_i + \vec{B}_i\right), \qquad \vec{J}_i = \frac{1}{\sqrt{Z_{0i}}}\left(\vec{A}_i - \vec{B}_i\right). \tag{2}$$

On the printed surfaces in the Fig.1, the boundary conditions on tangential fields are translated in terms of waves; the relation of fields on the metallic sub-domain (M) is $\vec{E}_1 = \vec{E}_2 = 0$, on the dielectric sub-domain (D), we see that $\vec{E}_1 = \vec{E}_2$ and $\vec{J}_1 + \vec{J}_2 = 0$, and on the source sub-domain (S), we propose that $\vec{E}_1 = \vec{E}_0 - Z_0(\vec{J}_1 + \vec{J}_2)$. We can write the scattering parameter (S) of wave diffraction in each sub-domain in equation (3). Where $n = \sqrt{Z_{01}/Z_{02}}$, $n_1 = z_0 / z_{01}$, $n_2 = z_0 / z_{02}$, $n_{12} = z_0 / \sqrt{z_{01} z_{02}}$, and M, D and S are equal to 1, we have,

$$[S] = \begin{bmatrix} -M + \frac{(1-n^2)D}{1+n^2} + \frac{(-1+n_1-n_2)S}{1+n_1+n_2} & M + \frac{(2n)D}{1+n^2} + \frac{(2n_{12})S}{1+n_1+n_2} \\ M + \frac{(2n)D}{1+n^2} + \frac{(2n_{12})D}{1+n_1+n_2} & -M + \frac{(n^2-1)D}{1+n^2} + \frac{(-1-n_1+n_2)S}{1+n_1+n_2} \end{bmatrix}. \tag{3}$$

Considering metallic box geometry, the set of functions associated to both TE and TM transverse electric fields provides an orthogonal basis function set suitable to expanded electric and magnetic fields. Hence, from equation (1), the waves can be expanded on the same set of basic functions of the tangential fields. The reflection coefficient, $\vec{\Gamma}$ on the bottom and top wall are written in equation (4), which $Y_{m,n}$ is mode admittance, and m, n are order of TE and TM modes,

$$\vec{\Gamma} = \sum_{m,n} \left| f_m > \frac{1 - Z_0 Y_{m,n}}{1 + Z_0 Y_{m,n}} < f_n \right| \quad \text{When} \quad Y_{m,n} = \sum_{m,n} \left| f^{\alpha}_{m,n} > Y^{\alpha}_{m,n} < f^{\alpha}_{m,n} \right|. \tag{4}$$

Iterative process, the principle of the wave iterative computation based on the repetition of the wave propagation process until problem resolving has been presented by using the wave relation equation as following.

$$\vec{A} = \vec{\Gamma} \times \vec{B} \text{ and } \vec{B} = [S] \times \vec{A} + \vec{B}_o. \tag{5}$$