DISCRETIZATION IN TRIANGULAR MICROSTRIP RESONATORS

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ABSTRACT

The triangular microstrip resonator with steps in the width is a way to simulate the triangular form by the triangular discrete, its analyze is made using the full wave and concise Transverse Transmission Line (TTL) method in the Fourier Transformed Domain (FTD), in conjunction with the Moment Method. Numerical results of the resonance frequency are presented in graphics in 2D and 3D with the use of the FORTRAN Power Station and MATLAB languages.

1. INTRODUCTION

Microstrip antenna can have different geometric forms, and most of them are rectangular. In the present paper the discretization in triangular microstrip resonators is analyzed. This is a modification of the rectangular resonator.

This study consists of the analysis of a structure with two dielectric substrates and a rectangular patch that is changed in the number of steps in its width. A consequence of this is that with a great number n, of steps that tends to infinite, makes the patch takes the triangular form.

The triangular microstrip resonator with steps in the width is analysed using the full wave efficient and concise Transverse Transmission Line (TTL) method in the Fourier Transformed Domain (FTD) [1-2], in conjunction with the Moment Method. Numerical results of the resonance frequency of this triangular microstrip resonator with steps in the width are obtained using a computational program developed in the FORTRAN Power Station language, using a 500 MHz microcomputer. These results are presented in curves in 2D and 3D obtained using the MATLAB for WINDOWS 5.0, showing the variations of the resonance frequency as function of the length, of the substrate thickness, of the width and of the different dielectric materials. The actual study brings a good contribution for microstrip resonators with new geometric forms, its respective peculiarities and analysis through the use of the precise full wave TTL method.

The results are very satisfactory and comparisons with other results of resonators are realised [3-5]. The fig. 1 shown the superior view of a two steps in the width triangular microstrip resonator is presented .

It's observed that making the number of steps n tending to infinite, the patch takes a better approximation to the triangular form. By this way if n goes very big, but no infinite, is obtained a triangular discretization patch, that is a good approximation of a triangular continue and has a simpler analyse.

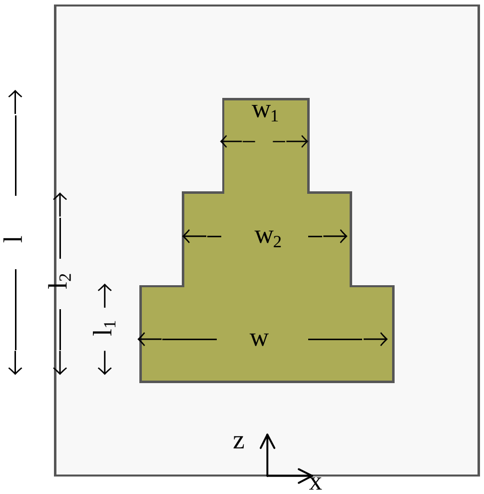

Fig. 1 Triangular microstrip resonator with two steps variation in the width.

2. THEORY

Considering the microstrip patch antenna, as a microstrip resonator, a set of equations that represent the electromagnetic fields in the x and z direction as function of the fields in the y direction are obtained applying the TTL method. Starting from the Maxwell's equations, the components can be used to represent the electric and magnetic fields, the transverse (y) and tangential (t = x and z) components to the resonator.

After various algebraic manipulations the general equations for the structure in the FTD are obtained. For example for the x direction,

$$\tilde{E}_{xi} = \frac{-j}{k_i^2 + \gamma_i^2}\left(\alpha_n \frac{\partial}{\partial y}\tilde{E}_y + \omega\mu_o \Gamma \tilde{H}_y\right) \quad (1)$$

$$\tilde{H}_{xi} = \frac{-j}{k_i^2 + \gamma_i^2}\left(\alpha_n \frac{\partial}{\partial y}\tilde{H}_y + \omega\varepsilon_i \Gamma \tilde{E}_y\right) \quad (2)$$

where $\gamma^2 + k^2 = \alpha_i^2 - \Gamma^2$ and α_i is the spectral variable.

After the application of the boundary conditions, the moment method is used to eliminate the electric fields in (3) and to obtain the homogeneous matrix equation with two variable in (4), for the calculation of the complex resonant frequency.

$$\begin{bmatrix} Z_{xx} & Z_{xz} \\ Z_{zx} & Z_{zz} \end{bmatrix} \cdot \begin{bmatrix} \tilde{J}_{zg} \\ \tilde{J}_{xg} \end{bmatrix} = \begin{bmatrix} \tilde{E}_{xg} \\ \tilde{E}_{zg} \end{bmatrix} \qquad (3)$$

Chosen appropriately the base functions and calculated the current densities in the spectral domain, are done substitutions in the equation (3).

Applying the inner product in (3) is obtained,

$$\begin{bmatrix} K_{xx} & K_{xz} \\ K_{zx} & K_{zz} \end{bmatrix} \cdot \begin{bmatrix} a_x \\ a_z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad (4)$$

The roots of this matrix determinant are the real and imaginary resonance frequency.

Making the number of steps very big, the patch is considered like a discrete triangle, with each value calculated as the following equations:

Calculation of the lengths,

$$\begin{aligned} l_1 &= \frac{l}{n+1} \\ l_2 &= l_1 + l_1 \\ l_3 &= l_2 + l_1 \\ &\dots \\ l_{n-1} &= l_{n-2} + l_1 \\ l_n &= l_{n-1} + l_1 \\ l &= l_n + l_1 \end{aligned} \qquad (5)$$

Calculation of the widths,

$$\begin{aligned} w_1 &= \frac{w}{n+1} \\ w_2 &= w_1 + w_1 \\ w_3 &= w_2 + w_1 \\ &\dots \\ w_{n-1} &= w_{n-2} + w_1 \\ w_n &= w_{n-1} + w_1 \\ w &= w_n + w_1 \end{aligned} \qquad (6)$$

where n is the number of steps, l is the total length and w is the total width.

Calculation of the number of segments "s" of the patch,

$$s = 2n + 1 \qquad (7)$$

3. RESULTS

The numerical results are obtained with the use of a computational program in the FORTRAN Power Station language, using a 500 MHz microcomputer. Curves are presented in 2D and 3D obtained using the MATLAB for Windows 5.0. The graphics shows the resonance frequency variation as function of the length, substrate thickness and width to different number of steps.

The Fig. 2 shows results in 3D of the resonance frequency as function of the length and of the width. Making the number of steps 0, is obtained a rectangular patch.

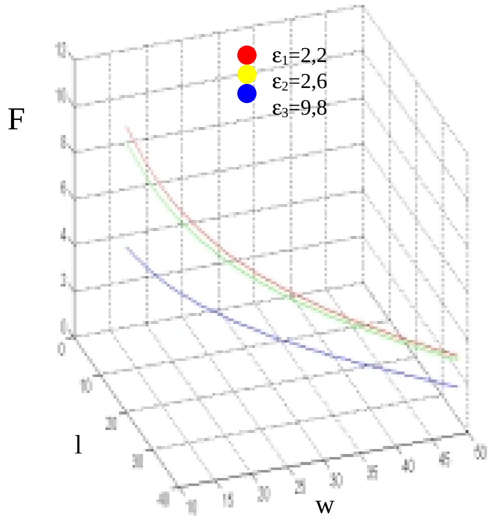

Fig. 2 Curves in 3D of the resonance frequency as function of the length and width, number of steps = 0.

The Fig 3 shows results of the resonance frequency as function of the relative permittivity and is in accordance with results of the reference [8].

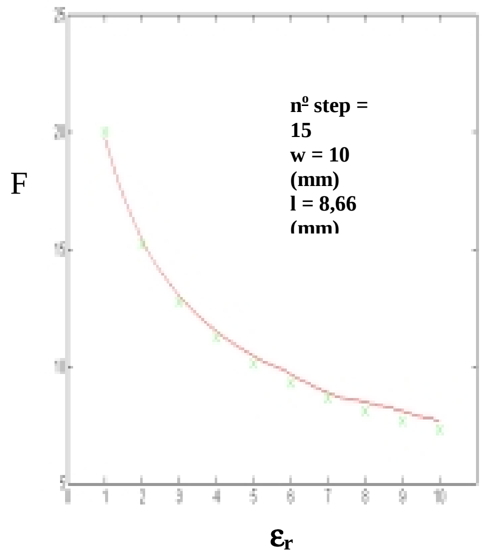

Fig. 3 Curve in 2D of the resonance frequency as function of the relative permittivity in the region 1.

The Fig.4 shows the real resonance frequency as function of the length, with ε_{r1} = 2.22 and ε_{r1} = 2.60, thickness = 0.7 mm, number of steps = 15, $\sigma_1 = \sigma_2$ = 0.0, ε_{r2} = 1.0, width = 14 mm and length = 8.66 mm .

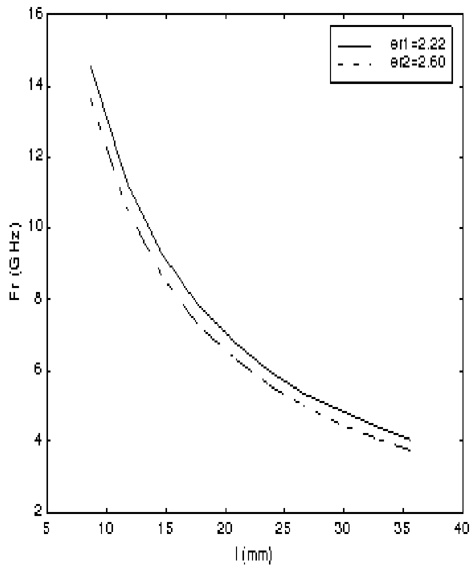

Fig. 4 Real Resonance frequency as function of the length for 15 steps.

Curves in 3D of real and imaginary resonance frequency are shown in fig. 5 and fig. 6, respectively, using the following parameters, thickness = 0.7 mm, number of steps = 15, σ_1 = 0.0, σ_2 = 0.0, ε_{r1} = 2.22, ε_{r2} = 1.0, width = 10.0 mm and length = 8.66 mm.

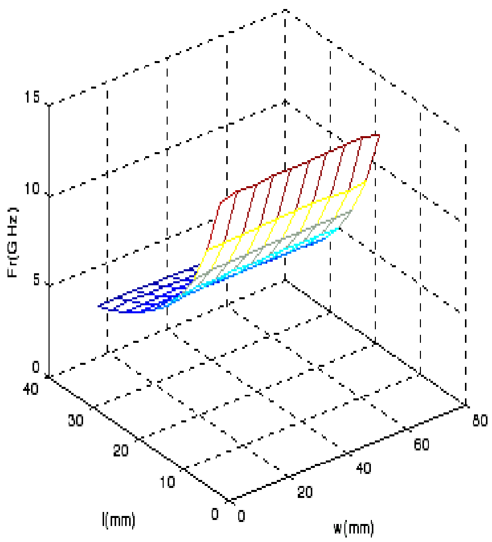

Fig.5 Curves in 3D of the real resonance frequency of a triangular microstrip resonators with 15 steps.

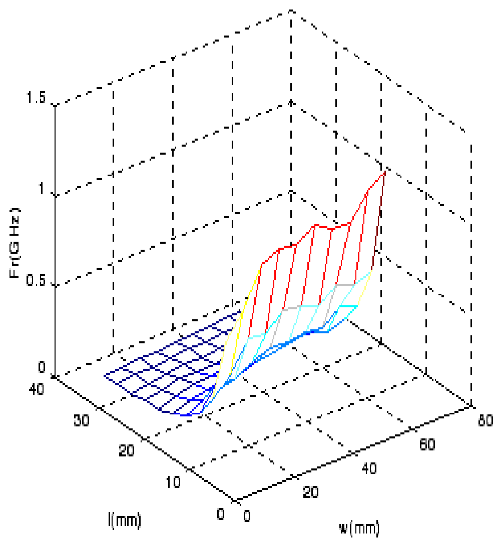

Fig.6 Curves in 3D of the imaginary resonance frequency of a triangular microstrip resonators with 15 steps.

4. CONCLUSIONS

The Transverse Transmission Line (TTL) with the Moment Method was used to analyse the new triangular microstrip resonator with steps in the width. This study brings a good contribution to develop the analyse of different patch geometry with the use of the full wave method TTL which is an excellent and versatile method that can be used with a lossless or loss as semiconductor substrate, in various structures. The results for the complex resonance frequency confirm the exactness of the TTL method applied to analyses with triangular microstrip resonator, facilitating its study and design.

Graphics in 2-D and 3-D that show the real and imaginary resonance frequency with relation to the patch width and length of the microstrip with steps resonator were presented. This work received financial support of CNPq

5. REFERENCES

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