New application to microstrip antennas with metamaterial substrate

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Abstract - The propagation characteristics of the rectangular microstrip patch antenna on metamaterial substrate are determined via full wave method, Transverse Transmission Line – TTL. Compared to other full wave methods, the TTL is an efficient tool to determine the resonant frequency, making possible a significant algebraic simplification of the equations involved in the process. Numerical results of resonant frequencies are found as functions of the metamaterial properties.

One of the major contributions of this work is in using the method TTL [1], which has significant algebraic simplifications as well as the consistent results. Another is in the choice of metamaterial substrate [2]-[5] that allows the use of such antennas (microstrip antennas). This artificial medium exhibits anisotropic properties with effective permittivity ε_{eff} and permeability μ_{eff} [2]-[5]. The MTM used in this studied can be characterized by the tensor matrix below [2]:

$$\vec{\mu} = \mu_0 \begin{bmatrix} \mu_{xx} & 0 & 0 \\ 0 & \mu_{yy} & 0 \\ 0 & 0 & \mu_{zz} \end{bmatrix} \qquad (1)$$

$$\vec{\varepsilon} = \varepsilon_0 \begin{bmatrix} \varepsilon_{xx} & 0 & 0 \\ 0 & \varepsilon_{yy} & 0 \\ 0 & 0 & \varepsilon_{zz} \end{bmatrix} \qquad (2)$$

The numerical-computational results are performed considering that the metamaterial has εeff = 9.8 and μeff = 3.1.The resonant size of the patch is calculated at 250 MHz, as presented in [3]. We consider enhanced positive electric permittivity and magnetic permeability for microwave applications. Results are obtained considering a possible configuration of the metamaterial tensors by considering the variations of the effective permittivity and permeability [6].

In Figure 1 numerical results are presented for the resonant frequency versus patch length with different values of effective permittivity along the same optical axis (z - axis). It appears that the antenna printed on a substrate with high dielectric constant has a low resonance frequency, which contributes to miniaturization of the device. The behavior of resonance frequency when the change occurs over μ_{eff} is similar to that observed in ε_{eff} as shown in Figure 2. Using the Ansoft HFSS®, the return loss of the structure with bianisotrópico substrate (h = 0, 127 cm) is obtained, as shown in Figure 3. It appears that for the square patch, with w = l = 9,3 cm, the return loss is -22 dB.

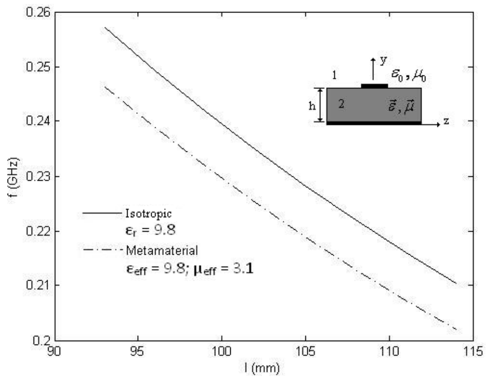

Figure 1 - Ressonance frequency as function the patch length

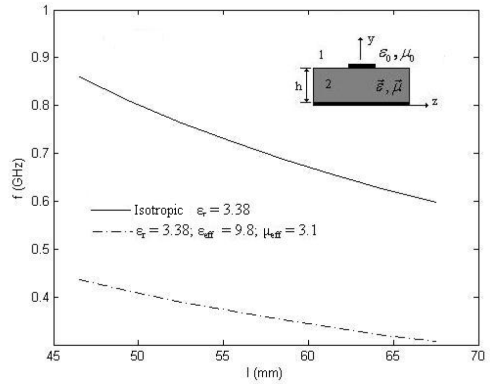

Figure 2 - Ressonace frequency as function the patch lenght

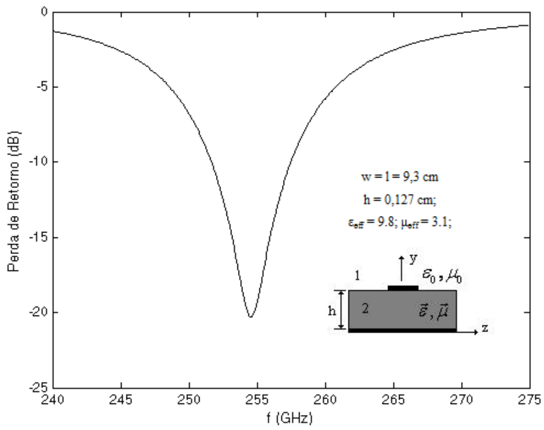

Figure3 – Return loss as function of the resonance frequency.

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