Recently, the wave propagation in waveguiding structures containing metamaterials has been subject to an intense investigation, mostly due to their promising applications to microwave and millimeter-wave guiding and radiating devices. Several types of waveguides involving metamaterials have been already addressed in the literature but, in most cases, this analysis has been limited to a single frequency operation.

In this paper, the effects of material dispersion and loss on the performance of some types of waveguides involving metamaterials are investigated [1]-[6]. A lossy dispersive Lorentz model is adopted for both the electric permittivity and the magnetic permeability. The dispersion properties and the modal equation root dynamics in the complex plane of the longitudinal wavenumber are analyzed.

The main goal of this article is to show that unphysical results may arise when simple dispersion models, disregarding losses, are adopted, therefore violating causality. In fact, according to the Kramers-Kronig relations, a causal dispersive metamaterial model must necessarily include the losses. In the absence of losses and for finite values of the constitutive parameters, unphysical resonances in the longitudinal wavenumber are reported. This unphysical behavior disappears when losses are considered in the material model. In fact, as soon as negligible losses are introduced, these resonances turn into improper leaky modes.

The propagation of lossy surface and leaky modes in this type of waveguides is also investigated and its performance is analyzed. Moreover, the effects of metamaterial dispersion and losses may suggest potential applications. Namely, it is shown that, in the presence of small losses, this waveguide exhibits sharp narrow passbands, hence suggesting its application in the design of waveguiding filters.

REFERENCES