A Generalized ZY Smith Chart for Solving Nonreciprocal Transmission Line Problems

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The *standard* Smith chart has shown to be a very useful tool when solving *reciprocal* transmission line problems, especially for visualizing transmission line phenomenon. Note that the reciprocal transmission line possesses the *same* propagation constant, β, and the *same* characteristic impedance, Z_o, for propagation in the forward and reverse directions. However, the standard Smith chart needs to be modified for *nonreciprocal* transmission lines, where they possess different propagation constants, β^+ and β^-, with corresponding characteristic impedances, Z_o^+ and Z_o^-, for propagation in the forward and reverse directions, respectively. An example of such a line could be a microstrip transmission line on a magnetized ferrite substrate. In this paper, the standard ZY Smith chart is generalized for nonreciprocal transmission lines.

First, the analysis of nonreciprocal transmission lines terminated in the load impedance Z_L will be given. It can be shown that the reflection coefficient at the load, Γ_L, is a function of Z_L, Z_o^+ and Z_o^-. Once Γ_L is obtained, the equations of resistance and reactance circles can be found analytically, and the *generalized* Z Smith chart can be constructed graphically by plotting a family of those circles on the reflection coefficient complex plane (Γ plane). Similarly, the *generalized* Y Smith chart can be constructed by plotting a family of the conductance and susceptance circles on the Γ plane, where the equations of these circles can be found from the expression of Γ_L. It can be shown that the generalized ZY Smith chart reduces to the standard ZY Smith chart when $Z_o^+ = Z_o^- = Z_o$, as expected. Some properties of the generalized ZY Smith chart will be discussed as well. Finally, several cases will be examined to verify the validity of the generalized ZY Smith chart. It is found that results obtained from the generalized ZY Smith chart agree very well with those obtained from direct calculation of associated formulas.