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Metamaterial device design with the extended modal theory

Metamaterial device simulation often requires full-wave analysis which implies high memory storage. The computer capacity is sometime not sufficient to solve the problem. To overcome this problem, homogenization techniques may be applied, the results are generally obtained faster. However, the method accuracy may be contested since the results are strongly dependent on the proposed approximations. For waveguide and horn antenna analysis, the extended modal theory (EMT) has been developed. This method is based on metamaterial representation by surface impedance that is dependent on frequency, incidence angle and mode order. They can be isotropic or anisotropic but are independent of the position on the surface. These impedances are then introduced in an analytical dispersion equation to get the propagation constant and consequently the electromagnetic field formulation. The EMT result accuracy is compared successfully to full-wave analysis with computation time reduction. Based on this EMT, a new design methodology is proposed. Firstly, dispersion diagram and field cartography are determined for fixed surface impedances (in frequency and incidence angle). Surface impedance ranges are determined with regard to these results. Then, metamaterials are optimized to satisfy these ranges. Reduced cross-section waveguide with metamaterial walls has been designed (30% smaller than conventional metallic waveguide) with comparable performances (cut-off frequency, fields repartition) thanks to this methodology. First interesting results are also noticed on opened-waveguide antenna performances. The presented designs have been done in rectangular waveguide, circular waveguides are under investigation.

Biography

Nathalie Raveu completed her MS degree in Electronics and Signal Processing in 2000 and PhD in 2003. She is a Professor at National Polytechnic Institute of Toulouse and Research Fellow at LAPLACE-CNRS (Laboratory of Plasma and Energy Conversion). Her research topics are oriented toward development of efficient numerical techniques to address innovative microwave circuits. During the last years, she has developed a new method for SIC's study, metamaterial horns and plasma cavity.

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