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# Assessing Effective Medium Theories for Designing Composites for Nonlinear Transmission Lines

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Nonlinear transmission lines (NLTLs) are interest because they can sharpen pulses to produce oscillations from 100 MHz to low GHz once their permittivity and permeability have saturated and the electromagnetic shockwave has formed [1]. NLTLs typical use nonlinear dielectrics such as barium strontium titanate (BST), nonlinear magnetic materials such as nickel zinc ferrites (NZF), or both nonlinear dielectric and magnetic materials to provide these shock waves. An alternative approach involves designing composites comprised of BST and/or NZF inclusions in a host material, analogous to electromagnetic interference designs incorporating inclusions of various shapes in a plastic to tune the composite's electromagnetic properties [2]. Appropriately designing NLTL composites requires predicting these effective properties and, eventually, the high power microwave systems comprised of them. This study benchmarks various effective medium theories (EMTs) [3] to predict the permittivity and permeability of various composites of BST and/or NZF inclusions in the linear regime (for a fixed voltage and current). We first apply EMTs to predict DC permittivity of BST composites and then to AC measurements of permeability and permittivity for BST, NZF, and BST/NZF composites. We describe preliminary applications of CST Microwave Studios to predict the effective permittivity and permeability and compare to experiment and EMTs.

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