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On Recent Progress in the Modeling of Nonlinear HPEM-Effects

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Extended Abstract

The analysis of nonlinear phenomena in the context of HPEM-coupling and HPEM-protection has a rather long history, also within the general context of Electromagnetic Compatibility. Typical nonlinear phenomena are given by the emergence of intermodulation frequencies or the occurrence of high-to-low frequency conversion, for example. An analytic modeling of such phenomena often is feasible if the considered nonlinearities are weak such that power series approximations can be applied. In case of strong nonlinearities analytic treatments become less meaningful and one often turns to circuit models of nonlinear problems which can be numerically analyzed and solved within a circuit simulator.
In this contribution we report on a nonlinear energy storage effect which has been discovered and validated in the context of HPEM-excitations of nonlinearly loaded loop antennas. The analysis of this effect involves classical methods of circuit modeling, numerical simulations, and experimental measurements [1, 2]. Here, the circuit modeling follows a usual treatment, utilizing Thévenin equivalents. This is particularly meaningful if only one nonlinear element is present in the problem.
For nonlinearly loaded receiving structures involving more than one nonlinearity a decomposition of the circuit problem into a linear and nonlinear part becomes more complex such that advanced methods of passive macromodeling become useful for an effective and systematic treatment of the problem [3]. Explicit studies of nonlinearly loaded metal structures and diode grids that make heavy use of passive macromodeling recently appeared in [4, 5]. Following this route it is possible to also study the above mentioned nonlinear energy storage effect for configurations with increased complexity, involving more than one nonlinear element. This is not only useful for the study of HPEM-coupling to nonlinearly loaded structures but also paves the way to potential applications such as HPEM-pulse detection or energy harvesting.

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