Electromagnetic Modeling of Ethernet Transformers

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Wideband ferrite core Ethernet transformers are commonly used for interfacing communication networks with computers. These transformers are designed to suppress common-mode signals and transmit differential-mode signals in the high frequency range (0.1MHz – 1GHz) with minimal distortions. To achieve this goal, the primary and secondary windings usually have the same turn numbers and they are wound together (intertwined) around ferrite cores with low losses. This intertwined winding arrangement is done on purpose to minimize leakage inductances of these windings in order to achieve flat transfer characteristics of these transformers in the desired high frequency range. However, the close proximity of the primary and secondary windings results in an appreciable cross-winding capacitance. This capacitance, on one hand, may be beneficial to the Ethernet transformer bandwidth. On the other hand, this capacitance serves as a channel for common-mode signals (noise). To suppress this channel, the midpoints of the primary and secondary windings are grounded.

In the talk, the unique features of Ethernet transformers will be reviewed and novel testing techniques for identification of lumped parameters of equivalent circuits will be presented. In these techniques, only peak value voltage measurements are used and, as a by-product, dispersion relations for complex magnetic permeability of ferrite cores are recovered. To account for the distributed nature of the cross-winding capacitance, novel distributed models for electromagnetic analysis of Ethernet transformers will be presented. It turns out that separate distributed models are needed for differential-mode and common-mode signals. The analytical and simulation results will be presented to illustrate the effectiveness of these distributed models.

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