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Stochastics Electromagnetic Field Propagation in Multiport Devices based on Transmission Line Segment Circuits and Wave Digital Networks

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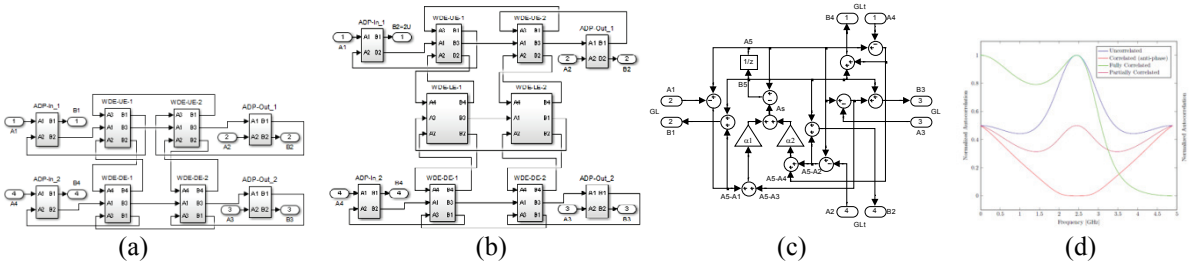
The full-wave electromagnetic (EM) analysis of modern electronic circuits and systems becomes computationally more and more costly as their complexity increases. The modeling of stochastic fields differs from the modeling of deterministic fields since the correlation between any pair of field samples have to be considered. For the correct modeling of stochastic electromagnetic fields the spatial correlations of the source distributions have to be considered. Stationary stochastic signals with Gaussian amplitude probability distribution can be completely described by their auto- and cross correlation spectra.

A combination of network-oriented design approach and correlation matrix methodology is used to provide an approach for efficient computation of stochastic EM field propagation in linear passive distributed microwave circuits [1-3]. Network synthesis techniques for lumped element equivalent circuits are used for network representation of multiport microwave circuits. The synthesized equivalent circuits are transferred into a wave digital network (WDN) model of the multiport. Stochastic modeling of multiport in z-domain is done. Time-discrete transmission line segment circuit algorithm is incorporated into the correlation matrix calculation to consider the propagation of stochastic signals in multiport device for an arbitrary correlation between the port sources. The sources can be correlated and in phase (fully correlated), correlated and in anti-phase, uncorrelated or partially correlated.

The examples for modeling stochastic input signals and their correlation information are given with four-port devices (dual-band branch-line couplers with two and three parallel lines). Branch-line coupler is one of the most popular passive circuit used for various microwave and millimeter-wave applications. The intensity and correlation of sources can be analyzed further.



(a) (b) (c) (d)

Figure 1.WDN models of multiport devices (dual-band branch-line couplers with two (a) and three (b) parallel lines); (c) General symmetrical four-port wave digital network (block models are formed based on it); (d) Autocorrelation spectra for WDN model given in (a) (input ports: 1 and 4; output port: 2)

1. J. A. Russer and P. Russer, "Modeling of Noisy EM Field Propagation Using Correlation Information", *IEEE Trans. on Microwave Theory and Techniques*, **63**,1, Jan. 2015, pp. 76-89, doi: 10.1109/TMTT.2014.2376962.
2. J. A. Russer, A. Cangellaris, and P. Russer, "Correlation Transmission Line Matrix (CTLM) Modeling of Stochastic Electromagnetic Fields", *2016 IEEE MTT-S International Microwave Symposium (IMS)*, San Francisco, CA, USA, 22-27 May 2016, 10.1109/MWSYM.2016.7540091.
3. B. Stošić, M. Haider, J. Russer, N. Dončov, and P. Russer, "Modeling of Propagation of Correlation Information of Stochastic Signals in Multiport Devices using a Wave Digital Filter Network", *Kleinheubacher Tagung – KH 2017*, Germany, Miltenberg, September 25-27, 2017.