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Foreword: Special Section on Addressing Signal and Power Integrity in Future Generation Systems. Part 2: Modeling Considerations

This Special Section is a collection of six articles highlighting the main directions that researchers from academia and industry are exploring for managing Signal and Power Integrity (SPI) through advanced modeling techniques. A previous Special Section (Part 1) on Addressing Signal and Power Integrity in Future Generation Systems presented eight papers in the two main categories of technological and design aspects. As in Part 1, the Authors were selected by looking at the best papers presented at two major IEEE conferences dedicated to SPI topics that are held annually in the United States (EPEPS2015, San Jose, CA) and Europe (SPI2016, Torino, Italy). Together, these two special sections give a good overview of leading research in advancing SPI in systems.

Modeling signal and power integrity is a key concern for engineers in the IEEE Components, Packaging and Manufacturing Technology Society. As the complexity of systems and the operating frequencies increase, the need for techniques that reduce model size, providing more efficient simulation and enabling multi-scale system representation becomes more important. The six papers in this Special Section are thus dedicated to modeling, analysis and simulation aspects, discussing full-wave electromagnetic solver improvements, reduced-order or compact modeling, as well as handling uncertainty.

Z. Peng *et al.* describes an approach for scalable full-wave electromagnetic analysis of electronic systems, from chip to package, board, and case. The method builds on a multi-scale formulation through hierarchical domain decomposition and parallel processing. Q. Dai *et al.* provide an elegant solution to the low-frequency breakdown of so-called Characteristic Mode Analysis, allowing a compact "modal" representation of the electromagnetic behavior of complex structures. Y. Tao *et al.* present a fast algorithm for variability analysis, building on parameterized Model Order Reduction (pMOR) and Numerical Inverse Laplace Transform (NILT). The result is a highly scalable and parallelizable algorithm for time-domain statistical analysis of circuits under stochastic parameter variations. Z. Zhang *et al.* describe a completely different approach, specifically targeting the curse of dimensionality associated with stochastic modeling and simulation in presence of many uncertain parameters (up to 40-60). The main keyword is here tensor recovery via low-rank approximations computed from few samples. N. Ambasana *et al.* propose an Artificial Neural Network (ANN) approach for estimating and reconstructing the dependence of Signal Integrity metrics, such as Bit Error Rate (BER), eye width and height, on design parameters. The objective is to automate those design tasks that usually rely on lessons learned or designer experience and know how. Finally, B. Nouri *et al.* describe an extension of classical projection-based Model Order Reduction (MOR) schemes, with the objective of preserving stability for system classes that are stable but non-passive, such as amplifier structures including interconnect parasitics.

Ensuring Signal and Power Integrity in electronic systems is a continuing challenge for future systems. The modeling aspects presented in this Special Section, along with the technological and design aspects discussed in Part 1 provide an excellent collection of leading research in these areas.

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