Foreword: Special Issue on Recent Advances in EMC of Printed Circuit Boards

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ADVANCES in technology and consumer demand have resulted in a continuous increase of clock rates and circuit density. Consequently, nonideal behavior of interconnects and components have become more and more important for the performance and EMC compliance of modern electronic devices and systems. Traditional models and rules of thumb have rapidly become inadequate to describe the physical effects taking place in high-speed electronic cards. In addition, the tendency toward high integration leaves less and less space for fixing design anomalies in a later stage of product development. In particular, all the major problems must already be solved before the testing phase, whereas design tuning on the prototype is highly undesirable since it has negative influence on the time to market.

Research activity has recently received a considerable momentum from such challenges, and new ideas and promising results start to appear at the horizon. This Special Issue presents a selection of significant contributions in the field of the electromagnetic compatibility of printed circuit boards (PCB). The following articles cover the state of the art and set future trends in four main topics that are related to some of the most relevant technical challenges of this field.

The first three papers are numerical studies that illustrate the application of computational techniques to the electromagnetic analysis of PCB structures. The contribution by Schuster and Fichtner presents a well-thought and in-depth analysis of spurious modes on PCBs, by means of the finite difference time domain method. The excitation and the influence of parasitic modes (like, e.g., surface waves or slotline modes) becomes a critical issue with the extensive use of high speed signals in multilayer and complex PCB structures. The power distribution in such structures is critical, since it may support the diffusion of the noise generated by switching digital devices. The contribution by Fan *et al.* presents an interesting formulation based on a mixed-potential integral equation that leads to a useful circuit model for design evaluation. A similar approach, presented by Archambeault and Ruehli and based on the well-known Partial Element Equivalent circuit, provides an effective tool for the assessment of various decoupling design strategies.

Interconnections represent a real challenge for the performance of new devices and systems for modern computer and multimedia applications. Various papers addressing different aspects of interconnects modeling are present in this issue. A thorough review of the characteristics for relevant types of interconnects at board and chip level is illustrated in the contribution by Deutsch *et al.* The main emphasis of this paper is on the frequency-dependent losses that affect the sustainable bandwidth for real applications. The approximation of frequency-dependent transmission-line parameters for certain types of controlled interconnects is addressed by the complementary paper by Williams and Holloway. The modeling of line parameters is an essential step to be dealt with before any performance analysis of long interconnects. The contributions by Grivet-Talocia and Canavero, and by Erdin *et al.* are dedicated to the simulation of signal propagation on multiconductor lines: the first paper presents an adaptive technique based on wavelets that is particularly suitable for time-domain simulation, and the second one discusses a reduced-order macromodel of the structure, that is able to account additionally for the effects of external interferences. The extraction of equivalents is also the subject of the papers by Nickel *et al.* (aimed at the extraction of modal parameters in the frequency domain), and by Scarlatti and Holloway (aimed at the extraction of equivalent circuit elements accounting for frequency dependence of the per-unit-length parameters).

Three interesting contributions are related to measurement techniques critically connected to PCB evaluation. The contribution by Namba *et al.* relates to the accurate estimation of the relative permittivity versus frequency over a very wide bandwidth, which is essential for the present digital applications; they describe a clever and practical method of measuring the relative permittivity of PCB material up to several gigahertz, and provide examples of its frequency dependence. The paper by Regué *et al.* deals with the estimation of electromagnetic emissions and with the detection of the potential causes of non compliance with standards; this paper provides an interesting method for both far-field prediction and radiating source identification from near-field measurements. The source identification is obtained as an application of a Genetic Algorithm. Finally, an assessment of the electromagnetic emissions of digital integrated circuits and of the test setup used to detect such emissions is presented in the paper by Fiori and Pignari, that provides a well-thought critical analysis of the correlation between voltage measurements on the test setup and the total radiated power due to the digital device mounted on its loading network.

The last five papers focus on specific applications dealing with PCB structures. The contribution by Ye *et al.* discusses a technique for reducing interferences produced by a multilayer PCB with a stack of power and ground planes. An alter-

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native technique, based on embedded capacitors, is proposed by Madou and Martens. Finally, circuit equivalents for SMD inductors are addressed in the paper by Naishadham, whereas far-end and microstrip crosstalk reduction are analyzed in the papers by Gazizov, and by Xiao *et al.*, respectively.

In conclusion, the Guest Editor wishes to thank the authors for their valuable contributions. A special appreciation must also be expressed to the reviewers. In fact, without their qualified efforts, this Special Issue would not have been possible. Lastly, the Guest Editor wishes to acknowledge the dedicated work that his colleague Ivan Maio has spent, helping to handle the submitted papers.

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