



18th International Zurich Symposium on Electromagnetic Compatibility

TUT-1 on Friday September 28

Circuit and numerical modeling of signal lines of a high-speed digital equipment for signal integrity and EMI compliance

Speakers:

S. Caniggia, EMC consultant, Italy

F. Maradei, University of Rome "La Sapienza", Italy

A. Orlandi and G. Antonini, University of L'Aquila, Italy

The tutorial will be addressed to the designers of high-speed digital equipment that wish to use simulation for signal integrity and EMI compliance. The tutorial will be divided in the following topics:

- **8-8.10**, S. Caniggia, *Presentation of the tutorial*
- **8.10-9.10**, G. Antonini, A. Orlandi, *Circuit Extraction for TL modeling of PCBs*
Numerical modeling of high speed interconnects requires the incorporation of frequency-dependent effects such as skin-effect, proximity effect and dielectric losses directly in time-domain to permit the link of models to non-linear simulators for performing transient analysis. It will be shown how to generate a rational model of 3-D interconnects based on advanced fitting techniques and its synthesis into a Spice-compatible equivalent circuit. In the case of interconnect supporting only the TEM mode it will be described a closed-form approximation providing directly a rational representation of the interconnect which is well suited for model-order reduction. Numerical examples will be given showing the capability of the proposed techniques to generate reduced models of high-speed interconnects which can be easily incorporated into Spice-like solvers.
- **9.10-9.50**, F. Maradei, *Circuit Extraction for TL modeling of cables*
It will be shown how to model coaxial and twisted pair cables for signal integrity valuation. Starting from S parameters computed numerically for an electrically short segment of the cable, it will be shown how an equivalent circuit based on simple circuit lumped elements can be obtained by using vector fitting technique in

frequency domain. Forming a cascade series of this equivalent circuit for the line length of interest, signal integrity simulation can be performed directly in time domain by using a SPICE-like circuit program. A main advantage of this procedure is that we are able to take into account all type of losses: radiation, skin and proximity effect.

- **9.50-10.10**, Coffe break
- **10.10-11.10**, S. Caniggia, *Numerical technique applied to a PCB with an attached cable for radiated emission investigations.*
It will be shown how to model structures such as PCBs with attached cables inserted in shielded box by using numerical codes. Several solutions for radiated emission reductions (grounding, filtering, partitioning, etc) will be verified by comparing the computed results.
- **11.10-12.00**, F. Maradei, *Mixed circuit and numeric technique to model a complex system with shielded cables under external interference.*
It will be shown how to model two shielded boxes interconnected by shielded cables with a casual routing in presence of an external interference such as an ESD event. The mixed technique consists on computing numerically the current on the shield of the cable. Once these currents are known, it will be presented equivalent circuits useful to compute interference within the cable. The key parameter in this procedure is the transfer impedance of the cable that is not simulated by commercial numerical codes.

Many of the models will be validated comparing computed results with measurements or comparing results obtained with different techniques.