From design to market of electronic systems: EMC engineering

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1. Introduction

Electromagnetic Compatibility (EMC) concerns with device - device interaction. More and more electrical - electronic devices have to operate in the same or close frequency bands and within closer distances, such as on-body health, telecommunication, and entertainment devices, wireless office equipments, etc. In terms of EMC effects near-field complex interference is of interest. A device or a system is said to be (electromagnetically) compatible if it does not cause interference with other systems, if it is not susceptible to emissions from other systems, and finally if it does not cause interference with itself. Therefore, the goal is to produce less interfering and less susceptible (i.e., highly immune) devices. An EMC problem has three components; the interfering source, the victim and coupling paths. Undesired interference may be eliminated by one of these three ways: (i) by suppressing the emissions at the source, (ii) by making the victim less susceptible (highly immune), and (iii) by removing the coupling path.

EMC engineering starts from early design and planning steps and continues all the way prototyping, testing, production, up to the marketing. EMC engineering is multi-disciplinary and has production problems, test/measurement procedures, standardization aspects, legal issues, etc. Educational problems are also very important therefore universities and educational institutions have been actively engaged in efforts to design new EMC curricula taking physics-based modeling approaches, observation-based parameterizations, and computer-based simulations into account.

This special issue includes papers covering almost all these aspects. Most of the papers are extended versions of the papers presented in the last (Jan 2009) EMC Zurich Conference which is one of the most prestigious EMC conferences in the World. The preparations started with my colleague, co-guest editor of this special issue, Prof. Dr. Ruediger Vahldieck from Department of Information Technology and Electrical Engineering (D-ITET) of the Swiss Federal Institute of Technology, ETH Zurich, Switzerland. Unfortunately, he has had serious health problems right after we sent out CFP of the special issue so I had to take over all the responsibility. I hope Prof. Dr. Ruediger Vahldieck totally recovers soon.

2. Papers

The first paper entitled "Construction and applications of the dirichlet-to-neumann operator in transmission line modeling" by T. Demeester, D. De Zutter, is from Department of Information Technology, Ghent University, Belgium. The authors discussed the Dirichlet-to-Neumann (DtN) operator which is a useful tool in the characterization of interconnect structures. They showed that this operator can be used for the calculation of the per unit length transmission line parameters of multi-conductor interconnections, or to directly determine the internal impedance of conductors if combined with the Method of Moments. They also illustrated the theory with some numerical examples.

O. O. Sy, M. C. van Beurden, B. L. Michielsen, and A. G. Tijhuis from Electromagnetics Group, Department of Electrical Engineering, Eindhoven University of Technology, The Netherlands proposed a stochastic method to characterize electromagnetic couplings involving geometrically perturbed transmission lines in their paper entitled "Variance and kurtosis-based characterization of resonances in stochastic transmission lines: local versus global random geometries". They presented a combined exploitation of suitably defined statistical tools to appreciate the intensity of the dispersion of response variables both physically via the variance, and statistically through the kurtosis or fourth-order moment. The usefulness of this method in analyzing the resonances was also illustrated by the study of a transmission line affected by two different types of random geometrical perturbations, viz. a local deformation modeled by a wavelet and global sinusoidal undulations.

The paper by K. Yeğin from Yeditepe University, İstanbul, entitled "Weak Penetration and Radiation through apertures in conducting bodies of revolution" discussed penetration through very small apertures in conducting surfaces with a particular interest in the determination of the field that penetrates holes in conducting bodies of revolution (BOR's) and the coupling of this field to an interior probe. K. Yeğin followed a different approach to determine the penetration for this problem, which yielded accurate results when the penetrated field is weak by using the reciprocity and the radiation paradigm. He applied alternative integral equation formulations to geometries of interest, used method of moment (MoM) in solving these integral equations, and showed that these methods yield accurate results in the determination of weak radiation, as well as for weak penetration.

The paper entitled "Experimental characterization and equivalent circuit extraction of nanowires for signal integrity applications" by G. Antonini, M. Di Clerico, A. Orlandi, V.Ricchiuti, M. Passacantando, and S. Santucci all from Italy, presented design steps of a printed circuit board used as test vehicles for the measurement of the electrical properties of carbon nanotube's deposit.

The paper entitled "Conductive EMI noise measurement for switched reluctance drive" by H. Chen, L. Cheng, X. Qiu, and Y. Zhao from China University of Mining & Technology and Nanjing Post and Telecommunication University, and Nanjing Normal University, Chinae described a new four-phase Switched Reluctance drive with the four-phase 8/6 structure double salient reluctance motor, the four-phase asymmetric bridge power converter and the 89C52 MCU digital controller. The conductive electromagnetic interference noise measurement equipment was described with the function of separated common-mode noise and differential-mode noise. The tested results of common-mode noise and differential-mode noise of the Switched Reluctance drive were also presented.

Fundamental educational aspects of EMC engineering were discussed in the paper entitled "EMC education at the University of Technology Zurich" which was parepared by G. Apaydın and N. Arı from Applied Research and Development, University of Technology Zurich, Switzerland. They illustrated educational issues

in electromagnetic compatibility (EMC) engineering in Switzerland and presented sample course contents and practical materials for EMC education at the University of Technology Zurich. Educational issues in EMC engineering was also discussed in the paper entitled "Electromagnetic compatibility engineering education: problems, challenges and perspectives" prepared by L. Sevgi, from Electronics and Communication Eng. Dept. of Doğuş University, İstanbul. L. Sevgi especially discussed EMC educational and training problems and challenges with the emphasis of the necessity of physics-based modeling (theory) and hands-on training (practice). An introductory level EMC lecture and a short course outline were also given for a modern EMC education.

A. C. Scogna from CST of America, MA, USA, and A. Orlandi from UAq EMC Lab, University of L'Aquila, Italy, in their paper "Two dimensional EBG structures for multiband noise mitigation" proposed a two dimensional electromagnetic Bandgap (EBG) structure for multi band noise mitigation in PWR/GND plane pairs. They achieved excellent noise suppression in multiple bands within the range 0-8GHz. They also studied signal integrity analysis by modelling a microstrip to stripline transition and by evaluating insertion loss, TDR as well as eye diagram.

The paper entitled "Development of a magnetic field model and insertion into a commercial electromagnetic simulator" by P. F. Lopez, C. Arcambal, Y. V. Gilabert, A. Ramanujan, D. Baudry, A. Louis, and B. Mazari, all from France presented a modelling procedure that requires magnetic near-field measurements and matrix inversion methods. They developed a magnetic field model based on equivalent sources (electric dipoles) placed on a plane within their institute IRSEEM. They used a near-field test bench with a loop antenna in order to quantify the tangential components of the magnetic field in amplitude and phase. Then, they used these data as input to determine the parameters of the model; the orientation in the plane and the current of each dipole. They inserted this model into one of commonly used commercial electromagnetic tool to make it useful in practice.

L. Štrac and F. Kelemen from Koncar Power Transformers Ltd., Žagreb, Croatia, and D. Žarko from University of Zagreb, Faculty of Electrical Engineering and Computing, Department of Electrical Machines, Drives and Automation, Zagreb, Croatia in their paper entitled "Modeling and calculation of electromagnetic field in the surroundings of a large power transformer" measured and calculated electromagnetic field quantities in the surroundings of a large power transformer with the aim to avoid the necessity of measuring the field on subsequent units and used a computer model instead. The influences of various objects located in the vicinity of the transformer during measurement were also analyzed and taken into account in a computer model by the authors.

G. Çakır, and M. Çakır from Electronics and Communication Eng. Dept., Kocaeli University, Turkey, and L. Sevgi from Electronics and Communication Eng. Dept., Doğuş University, İstanbul, Turkey developed a novel FDTD-based virtual electromagnetic compatibility tool for the prediction of electromagnetic emissions from a multilayer printed circuit board. They introduced their package in the paper entitled "Electromagnetic radiation from multilayer printed circuit boards: A 3D FDTD-based virtual emission predictor". They performed interesting tests with characteristic structures and presented sample simulation results.

Field Programmable Gate Arrays (FPGAs) are on field programmable device which can be designed for different applications with various types of software available for synthesis purposes. The paper "VLSI-cell placement technique for Architecture of Field Programmable Gate Array (FPGA) design" by A. Verma and S. Dhingra from Institute of Instrumentation Engineering, Kurukshetra University, India, and M. K. Soni from Carrier Institute of Technology and Management, Fraidabad, India discussed Field Programmable Gate Array

(FPGA) with an interesting application. Finally, N. Wright from EMC PARTNER AG, Switzerland in his paper entitled "New ESD standard and influence on test equipment requirements" discussed the IEC61000-4 series of standards which form a basic framework for the immunity and emission testing of electrical and electronic equipment.

Acknowledgment

The initiation of the study of this special issue went back to March 2008 and was conceived by Prof. Dr. Kemal Leblebicioğlu, former editor-in-chief (EIC) of TJEECS (ELEKTRİK), just after the third special issue prepared under my guest editorialship, entitled "From Engineering Electromagnetics Towards Electromagnetic Engineering" and dedicated to the 75tm birthday of Prof. Raj Mittra was published. The initiation of my collaboration with Prof. Leblebicioğlu went back to 2000 just after he took over the EIC position. ELEKTRİK was then a local journal which was not listed in any of the prestigious endexes. In ten years time, starting from January 2008, and after a long exhausting team work ELEKTRİK finally succeeded to be indexed within Science Citation Index-Expanded (SCI-E) database. Most of the credit of this success belongs to Prof. Leblebicioğlu. He will always be remembered as the EIC who placed ELEKTRİK within SCI-E index.

Prof. Leblebicioğlu and I had had many discussions in the last decade and we prepared many special issues under my guest editorialship. The first special issue was in 2002, on "Complex Electromagnetic Problems & Numerical Simulation Approaches", dedicated to the 75tm birthday of Prof. Leopold B Felsen which attracted nearly 20 experts all around the World many of whom were IEEE Fellows. The second special issue was on "Electrical and Computer Engineering in the 21st Century: Issues, Perspectives and Challenges" and published in January 2006. As mentioned above, the third one was published in March 2008. This is the fourth one scheduled for December 2009. The last one will be on "Sky- and Ground-wave High Frequency (HF) Radars: Challenges in Modeling, Simulation and Application" which will be published in March 2010. The aim of all these issues was to see ELEKTRİK listed within the SCI. I'm very happy to see that ELEKTRİK has been included in the SCI-E index since January 2008. I feel happy if tiny piece of this success belongs to these special issues.

I express my deep gratitude to all contributing authors, the reviewers, and former EIC Prof. Dr. Kemal Leblebicioğlu for his kind invitation. I also thank to Prof. Dr. Sadık Kara, current EIC, Dr. Abdurrahman Aliy, Head, and Mr. Adnan Bahadır, Deputy Head of the Publication Department of Scientific Journals of TÜBİTAK, Mr. Erol Kılıç, Journal Administrator, Mr. Dale Allen Ross, English Editor, and Abdullah Can, Meral Esi, Typing & Figure Preparation, for their efforts during the preparation of the Issue for publication.