Research Networking Programmes

Science Meeting – Scientific Report

***Proposal Title**: 7th Workshop on Integral Techniques for Electromagnetics (INTELECT'2013)*

***Application Reference N°**: 5036*

1) Summary

Workshop INTELECT 2013 was organized with the goal of exchanging ideas and experiences in the analysis electromagnetic structures based on integral approach, as well as in the development of accurate and efficient software for designing electromagnetic devices. After the success of Lausanne, Switzerland (2007), Chiclana, Spain (2008), Istanbul, Turkey (2009), Diablerets, Switzerland (2010), Florence, Italy (2011) and Sevilla, Spain (2012), this year workshop was organized in Dubrovnik, October 14 – 15, 2013. As in previous editions, the workshop was actually informal gathering of academia researchers and commercial code software developers. We tried to offer a programme that is both relaxed and intensive, providing a unique frame for discussions between specialists of the integral side of electromagnetic analysis and software development. After each presentation there was a discussion about challenges and difficulties related to presented topic. In other words, everybody shared their ideas with others and get valuable feedback. At the end, all agreed to organize the workshop again next year probably in Switzerland

This year our special guest were the experts in areas where complex electromagnetic structures are also extensively analyzed, and which have not yet been the subject of interest of research who traditionally come to INTELECT workshops. Two areas that were covered this year are design of optical devices and electromagnetic compatibility tasks.

It is expected that the Workshop presentations will evolve into a convened session in the next EuCAP'2014 (The Hague, The Netherlands, 6-11 April 2014.).

Technical information:

Dates: 14/10/2013 – 16/10/2013
Venue: Center for Advanced Academic Studies, Address: Don Frana Bulića 4 HR-20000, Dubrovnik, Croatia
Organizing institutions: Ecole Polytechnique Fédérale de Lausanne (EPFL) and University of Zagreb (UNIZAG)
Organizers: Juan Mosig (EPFL), Zvonimir Šipuš (UNIZAG)

Material: All speakers got official backpack with all the materials in it: program and abstracts, CD with proceedings, and brochure with most interesting information's about Dubrovnik.

Sponsorhip:
(a) NEWFOCUS – the travel expenses and accommodation of several researchers attending the workshop were covered with the grant. Furthermore, the workshop dinner was also financed. In more details (the used exchange rate between Euros and Kunas is 1: 7.64 - the exchange rate of Croatian National Bank at 13.12.2013.):

- **1497 Euros** -Travel expenses for scientists with financial troubles (Prof. Angelo Freni, and Prof. Oleksander Nosich), for guest researchers of the Workshop (Dr. Dubravko Babic) and for a Ph.D. student without funding (Mladen Vukomanovic):
- **330 Euros** - Accommodation for scientists with financial troubles (Prof. Angelo Freni, and Prof. Oleksander Nosich).
- **506 Euros** – Workshop dinner in Orhan restaurant, Dubrovnik.
- **94 Euros –** Local administrative cost

The total cost is **2427 Euros** (the difference of 27 Euros will be covered internally).

(b) KoREMA (Croatian Society for Communication, Computing, Electronics, Measurement and Control) has paid the cost of renting the conference room, the cost of backpack with all materials, and the cost of coffee breaks (approximately **800 Euros**).

2) Description of the scientific content of and discussions at the event

The aim of the workshop was to exchange experiences in developing analysis methods of electromagnetic problems based on integral equation approach. Special attention was given to new methods of analysis as well as to the efficient numerical implementation into electromagnetic solvers. Abstracts of the presentations are given below.

Mauro Bandinelli: High-fidelity Electromagnetic Modeling of Complex Platforms From kHz's to GHz's
Industrial applications in the field of antenna design, antenna siting and EMC problems have some main requirements: i) to reduce the distance between the real configuration of the object under examination (i.e. the CAD model) and the meshed model used for simulation; ii) to allow for wide-band analysis on multi-scale models (i.e. to avoid the need of customizing the mesh model to each frequency band, as sometimes is unfortunately required to prevent ill-conditioning problems); iii) to allow full-wave analyses on electrically larger and larger objects (i.e. to move towards higher frequencies the need to switch to asymptotic methods); iv) to be able to perform the analyses in a reasonable time on common HW configurations (i.e. compatible with common engineering workflows). The results obtained with respect such requirements by the Computational ElectroMagnetic Laboratory (CEML) of Ingegneria dei Sistemi S.p.A (IDS) through a MR (Multi-Resolution) preconditioned MLFMA (Multi-Level Fast Multipole Algorithm) technique are shown, by referring to real-life EMC and HIRF problems on aeronautical and space platforms. Desiderata about next future developments to improve requirements satisfaction are discussed

Felipe Vico-Bondía, Miguel Ferrando-Bataller: A High Order Locally Corrected Nystrom Scheme for Charge-Current Integral Equations
A high order Nystrom scheme is developed for electromagnetic scattering problems of smooth objects. The implementation is based on different charge-current formulations.Charge-current integral equations have been used to overcome low and high frequency issues of classical integral equations like the EFIE and MFIE. In this paper we implement a high order Nystrom scheme based on a generalized Gauss quadrature rule for triangular elements. On one hand, the high order quadrature rule allows to obtain high accuracy in the solution for smooth geometries with a relatively low number of degrees of freedom. On the other hand, the second kindness of the integral equation used provides low condition numbers, immunity against high density mesh or refinement breakdown. A special purpose quadrature technique is used to compute correctly the singular integrals on the diagonal elements. As a result we present a high order implementation of charge-current formulations that allow to obtain up to 4-10 digits of accuracy in the near electric and magnetic scattered field for certain simple geometries and a wide range of frequencies.

Siniša Antonijević, Dragan Poljak: Some optimizations of the Galerkin-Bubnov Integral Boundary Element Method

Galerkin-Bubnov Integral Boundary Element Method (GB-IBEM) is used to model transient phenomena on thin wire structures directly in the time domain. One of the most prominent limitations of the method is the inability to deal with the structures above finally conducting half plane, due to the high computational inefficiency when ground losses are accounted for in the numerical model. In this paper it has been shown that GB-IBEM can be significantly optimized if real conductivity of the ground is considered. Inclusion of ground conductivity drastically decreases the computational efficiency by increasing the overall calculation time of original GB-IBEM numerical model, since it incurs rather complicated time dependent convolution integrals that have to be evaluated during each time step. It has been shown that using RC function that does not include Bessel functions significantly reduces the computational burden of evaluating these convolution integrals. In addition, it allows for recursive analytical evaluation of convolution integrals, which further alleviates the efficiency problem. Final optimization is achieved via elimination of redundant evaluations of the convolution integral. This optimization increases memory cost and requires additional preprocessing step of searching for source to observation node distances that result in duplicate evaluations, but can lead to an order of magnitude improvement in overall calculation time. Although considerable improvement has been made by modifying GB-IBEM with described optimizations, the resulting method is still approximately order of magnitude slower when taking into account the ground conductivity. However, it should be noted that no additional approximations are used through presented modifications, so introducing additional approximations at the cost of accuracy reduction is one possible venue for further improvements. Another possibility is using accelerating algorithms, such as Fast Fourier Transform Marching-On-in-Time algorithm (MOT-FFT). Subsequent papers on the subject of GB-IBEM optimization are planned to explore some of these possibilities.

Bartosz Bieda, Piotr Slobodzian: Computational Difficulties Related to Green's Functions for Longitudinal Current Sources Radiating inside Waveguides and Cavities

This paper describes computational difficulties, which arise within the IE-MoM approach when calculating reaction integrals related to longitudinal current distributions radiating inside waveguides or cavities. The difficulty consists in fast reaching the double precision floating point overflow before convergent results are obtained. This numerical instability prevents us from using higher number of modes (more than 10E+03 modes) in the numerical evaluation of modal series. The origin of such behavior is explained and a method for overcoming the described problem is proposed. It is shown that the method enables more than 150E+03 modes to be used without approaching the floating point overflow, i.e. the number of modes that can be safely used in calculations has been increased by more than an order of magnitude.

D.M. Solís, F. Obelleiro, J. M. Taboada, L. Landesa, J. O. Rubiños: Fast-Converging Integral Equation Formulations for Penetrable Bodies in Optics

Owing to recent advances in nanotechnology, plasmonics has become a prosperous field of science that exploits the subwavelength confinement, enhancement and directional control of light in the vicinity of metal-dielectric boundaries and metallic nanoparticles. Due to these unusual electromagnetic capabilities, we are witnessing a dramatic growth on both the number and scope of plasmonic applications. Despite the great advances achieved to date, the design of plasmonic nanosystems is still a challenging task. At radio frequency, metals are usually considered as perfect electrical conductors supporting only surface electric currents. At optical frequencies, however, the penetration of fields cannot be neglected, and the precise plasmonic electromagnetic response of metals as given by their complex dielectric constant must be taken into account. This makes it impossible to directly downscale the microwave traditional designs to the optical regime. Consequently, there is an increasing demand for rigorous and efficient tools to accurately handle arbitrarily shaped plasmonic systems. Fortunately, the optical response of metals is well described by classical electrodynamics. In this presentation, the surface integral equation (SIE) formulation and the multilevel fast multipol algorithm (MLFMA) are applied to the solution of large-scale plasmonic problems in the context of nanoscience and nanotechnology.

Dubravko Babic: Eigenvalue Problems in Open Resonators with Distributed Mirrors

Diffraction and distributed nature of quarter-wave mirrors play a central role in forming transverse-modes of gain-apertured vertical-cavity surface-emitting lasers (VCSELs). This paper reviews an integral-equation approach to determining the modes and associated propagation constants in such resonators. The iterative approach to solving open resonators is a useful and relatively simple tool to implement in resonators with distributed mirrors, apertured gain and loss regions of arbitrary lateral profile. In high-quality planar resonators, diffraction loss is small and paraxial approximation is generally a good approximation when looking for normal modes. Under these conditions, planar distributed mirrors may be replaced with hard mirrors located at a suitable distance away from the physical mirror surface. Numerous interesting problems remain to be analyzed in VCSEL resonators: (a) what is the shape of the resonator that results in highest single-mode discrimination ratio for a given fundamental mode loss, (b) is it possible to adapt the integral-equation approach presented here to treating bowed mirrors to break the polarization degeneracy in the resonator and optimize polarization locking, and, finally, (c) how would one apply the iterative integral-equation solution approach to resonators with sub-wavelength reflectors.

Anja Skrivervik: What Can Integral Equations Do for Arrays Analysis?
Large array problems have been of interest since many years, and their efficient study and design is still a challenge today. In this talk, classic approaches like the "element by element" approach or the "periodic boundary conditions" will be briefly reviewed in the specific frame of Integral Equation formulations. Then, the problem of large but finite arrays will be addressed thorough the windowing technique. Finally, an iterative approach to the study of general arrays will yield valuable information on the precision of the above mentioned approached, and will open new viewpoints on this classic problem.

Angelo Freni: A Hybrid ACA-MLayAIM Technique for the Analysis of Metasurfaces
Recently, a technique called MLayAIM, based on a modification of the classical method of moments (MoM) approach, has been developed for the analysis of large patch arrays [1], [2]. The key feature of this method is to introduce a neighborhood distance separating two regions: a near-interaction region and a weak-interaction region. The MoM matrix is then divided into the sum of a strong- and a weak-matrix. The near-interaction region requires that several reaction integrals be evaluated and stored in the strong-matrix, which is a sparse matrix. The computational efficiency is then fully achieved when the Green's function can be approximated, in weak region, by using a convenient factorized form. This allows us to operate a canonical grid expansion of the exact weak-matrix elements into a series of translational invariant terms times a function of the height differences between the basis and weighting functions. When an iterative solver is used, the matrix-vector product can be performed rapidly due to the sparse nature of the strong-matrix and the use of the fast Fourier transform (2D-FFT) and its inverse for the weak-matrix multiplies. This reduces the CPU time per iteration to $O(N\log_2 N)$ and the memory requirement to O(N). No restrictions are present on the thickness and the number of dielectric layers that separate each metallization or the vertical conductors can cross.
In case of analysis of planar arrays that makes use of artificial magnetic surfaces several pins and large vertical metallizations are however present. In this case, the number of non-planar basis functions grows rapidly and in consequence also the dimension of the strong-matrix. Even if usually the dynamic memory of the modern computers is sufficient to manage the problem, the filling time and the solution time increase significantly. The complexity of the method quickly decreases from O(N log2 N) to O(N1.5). The solution to this problem is based on the hybridization of the MLayAIM with the Adaptive Cross Approximation (ACA) method. Specifically, the latter is used to approximate the strong-matrix. Although the ACA method is very efficient for quasi static problems, it has also been recently applied to antenna problems with success. The main advantage is that the algorithm is purely algebraic; therefore, its formulation and implementation are integral equation kernel (Green's function) independent. This will allow us to preserve the original architecture of the MLayAIM software changing only the subroutines related to the strong-matrix. The complexity of the overall hybrid MLayAIM-ACA method is preserved to O(N log2 N).

Guido Valerio: Numerical-Asymptotic Synergic Approach for Speeding up the Filling Time in a MoM/Mode Matching Code for Large SIW structures
We propose a fast and accurate method-of-moments (MoM) formulation capable of analyzing electrically large substrate-integrated-waveguides (SIW) consisting of stacked parallel-plate waveguides (PPW) hosting dielectric or metallic posts and coupling and/or radiating slots. Slots are modeled by equivalent magnetic currents. The MoM matrix entries are expressed as a sum of a free-space, PPW, and post-scattering contribution. The free-space term is simply computed through the half-space Green's function, known in closed form. The PPW Green's function is expressed in terms of a radial transmission-line representation, converging much faster than the alternative *z*-transmission-line representation for larger radial dimensions. The post scattering is expressed as a series of cylindrical vector wave functions, whose amplitude is determined through the solution of a Mode Matching (MM) which enforces suitable boundary conditions on the post surfaces. This leads to an efficient representation, and to an easy control of the degree of accuracy achieved. Several substantial accelerations are proposed to exploit various symmetries of the structures, and to select the optimal number of modes according to the relevant geometrical and physical parameters. Furthermore, a novel spectral formulation is proposed here for the coupling integral between a cylindrical wave with arbitrary radial wavenumber and azimuthal dependence, and a slot. The computation of this integral is necessary to set up the MM, and it is performed for any testing function – cylindrical wave combination. The two-fold spatial integral defining the coupling is transformed into an equivalent one-fold spectral integral, the integration path of which is selected to obtain Gaussian decay of the integrand by locating a steepest-descent path (SDP). Both propagating and evanescent cylindrical modes are considered. A study of the numerical error made is presented, in connection with the choice of the number of quadrature points. The acceleration reached in the computation tile is quantified as the relevant parameters (e.g., slot-post mutual distance, slot size) vary, with examples of realistic structures. The complete formulation is validated by comparisons with results obtained by finite-elements commercial software and

measurement of in-house built prototypes. Specifically, we will analyze multi-waveguide SIW filters, electrically large SIW antennas with a great number of fine details, and a slot-based near-field focusing antenna.

Roberto D. Graglia, Andrew F. Peterson, Ladislau Matekovits, Paolo Petrini: Performances of Additive Singular BasisFunctions for Triangles

The numerical performance of recently developed families of singular hierarchical scalar and vector basis functions for modeling corner singularities is discussed. The basis functions defined on triangular cells are of the additive kind, with the singular basis functions superimposed to a full set of existing hierarchical nonsingular polynomial basis functions to form the representation. The presentation aims at illustrating the accuracy and the cost of the procedure as the number of degrees of freedom is systematically incremented to deal with canonic and non-canonic shapes**.**

Alex Nosich: Wave Scattering by Many Thin Material Strips: Singular Integral Equations, Meshless Nystrom Discretization, and Periodicity caused Resonances

Dielectric and noble-metal nanosize strips are attractive as easily manufactured components of optical antennas and sensors. In particular, metal nanostrips illuminated by a transversely-polarized light are known to display intensive localized surface-plasmon resonances in the visible and far-infrared ranges. The typical dimensions of metal nanostrips are the width from 100 to 1000 nm and the thickness from 5 to 50 nm that is 8 to 180 times smaller than the wavelength in the whole visible band (400 to 900 nm).

Despite wide use of FDTD codes, advanced computational methods used in the optical modeling of nanostrips include volume and boundary integral equations (IEs), where the integration domain is the area of the strip cross-section and its closed contour, respectively. Boundary IEs are considered more economic however typical number of unknowns is in thousands and still many forms of them possess spurious eigenvalues (real-valued false eigenfrequencies). To avoid this, one should use so-called Muller’s boundary IE; still the shape of the contour and its non-smoothness greatly affects the rate of convergence. All mentioned becomes even more important for multiple metal strips. Our suggestion is that, in the case of the strip thickness being only a small fraction of the free-space wavelength, the analysis can be simplified by neglecting the internal field and considering only the external field limit values. This enables reduction of the integration contour to the strip median line where the generalized boundary conditions (GBC) are imposed. To satisfy Helmholtz equation and radiation condition, we seek the scattered field as a sum of the single-layer and double-layer potentials, where unknown functions are magnetic and electric effective currents induced on the strips. Using GBC, we obtain two independent sets of IEs of the second kind –one for each type of current. One of them contains equations with logarithmic-type singularities and another with hyper-type singularities. We have recently developed a novel Nystrom-type discretization of the median-line IEs and applied it to the scattering by dielectric and metal strips. The chosen quadrature formulas ensure rapid convergence of numerical solutions to the accurate ones. In nano-optics, our approach opens possibility of reliable modeling of the scatterers consisting of hundreds of noble-metal strips such as multi-frequency optical antenna arrays, plasmonic sensors, and plasmonic solar cells.

Zvonimir Sipus, Marko Bosiljevac: Simplifying the Design of Complex Electromagnetic Structures using Green's Functions based on Asymptotic Boundary Conditions

Analysis of electromagnetic devices that contain periodic structures is a difficult and time-consuming task. Initial design of such components can be made in a short period of time using Green's function for canonical structures where the periodic structure is taken into account in the asymptotic sense. Consequently, it is possible to determine the basic dimensions of the considered electromagnetic structure, and therefore significantly shorten the time needed to obtain the final design (which will be done using a general electromagnetic solver and optimization procedure). Furthermore, with the help of the simplified analysis it is possible to calculate the parameters of interest (e.g., radiation pattern, mutual coupling level, etc.). This paper will present several models of periodic structures that accurately describe the observed structure, i.e. in which all the relevant mechanisms linked to the guiding and interaction of electromagnetic waves are considered. By comparing the results obtained using general electromagnetic solver and using the presented method we will demonstrate the accuracy and benefits of the proposed method in the design of electromagnetic devices that contain periodic structures.

3) Assessment of the results and impact of the event on the future directions of the field (up to two pages)

We believe that the workshop INTELECT 2013 was very successful. The following goals are achieved:

1. Open discussion about difficulties, which the scientists have encountered in their research, was present at the workshop. In the held presentations the scientists have shown not only the mature results, but also research attempts that were not successful till now, i.e. research that have not been completed. Therefore, we believe that the participants of the workshop got inspiration how to overcome the difficulties that have encountered.

2. There have been a lot of discussions about future cooperation between the groups. In informal atmosphere the joint projects were discussed, new joint research topics were considered, as well as the exchange of researchers between universities.

3. The researchers were interested in the application of analysis methods in other technical areas. In particular, the lecture of Dr. Dubravko Babic was of particular interest. He gave an overview of problem types that encounter in the construction of optical devices (e.g. in construction of VCSEL laser diodes) and researchers have recognized that the methods developed in the microwave frequency band can be easily be transformed to the optical frequency region.

4. The experts from commercial companies that develop electromagnetic solvers were present. They showed interest to implement some of solutions in their commercial products.

5. Everybody agreed that the workshop should be organized again next year, and they also showed interest to attend next-year workshop. Probably the workshop will be organized in Switzerland in autumn.

Annex 4.a: Programme of the meeting

Monday, 14 October 2013, 14h30-18h10

14:30 – 14:40 Welcome to INTELECT'2012 J.R. Mosig, EPFL Switzerland

14:40 Mauro Bandinelli (IDS Ingegneria Dei Sistemi S.p.A, Pisa, Italy)
High-fidelity Electromagnetic Modeling of Complex Platforms from kHz's to GHz's

15:10 Felipe Vico-Bondía and Miguel Ferrando-Bataller (Universidad Politécnica de Valencia, Spain)
A High Order Locally Corrected Nystrom Scheme for Charge-Current Integral Equations

15:40 Siniša Antonijević and Dragan Poljak (University of Split, Croatia)
Some optimizations of the Galerkin-Bubnov Integral Boundary Element Method

16:10 Coffee break

16:40 Bartosz Bieda and Piotr Slobodzian (Wroclaw University of Technology, Poland)
Computational Difficulties Related to Green's Functions for Longitudinal Current Sources Radiating inside Waveguides and Cavities

17:10 D.M. Solís, F. Obelleiro, J. M. Taboada, L. Landesa, and J. O. Rubiños (University of Vigo and University of Extremadura, Spain)
Fast-Converging Integral Equation Formulations for Penetrable Bodies in Optics

17:40 Dubravko Babic (University of Zagreb, Croatia)
Eigenvalue Problems in Open Resonators with Distributed Mirrors

20:00 Workshop dinner

Tuesday, 15 October 2013, 08:30 – 12:00

08:30 Anja Skrivervik (Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland)
What Can Integral Equations Do for Arrays Analysis?

09:00 Angelo Freni, P. De Vita and M. Bandinelli (University of Florence and IDS Ingegneria Dei Sistemi S.p.A., Italy)
A Hybrid ACA-MLayAIM Technique for the Analysis of Metasurfaces

09:30 Guido Valerio (Université de Rennes 1, France)
Numerical-Asymptotic Synergic Approach for Speeding up the Filling Time in a MoM/Mode Matching Code for Large SIW structures

10:00 Coffee break

10:30 Roberto D. Graglia, Andrew F. Peterson, Ladislau Matekovits and Paolo Petrini (Politecnico di Torino, Italy)
Performances of Additive Singular Basis Functions for Triangles

11:00 Alex Nosich
(Institute of Radiophysics and Electronics NASU, Kharkiv, Ukraine)
Wave Scattering by Many Thin Material Strips: Singular Integral Equations, Meshless Nystrom Discretization, and Periodicity caused Resonances

11:30 Zvonimir Sipus and Marko Bosiljevac (University of Zagreb)
Simplifying the Design of Complex Electromagnetic Structures using Green's Functions based on Asymptotic Boundary Conditions

Annex 4.b: Full list of speakers and participants

No.	PARTICIPANT	INSTITUTION	COUNTRY
1	Juan R. Mosig	Ecole Polytechnique Fédérale de Lausanne, Laboratoire d'Electromagnétsime et d'Acoustique, CH-1015 Lausanne	Switzerland
2	Anja Skrivervik	Ecole Polytechnique Fédérale de Lausanne, Laboratoire d'Electromagnétsime et d'Acoustique, CH-1015 Lausanne	Switzerland
3	Mauro Bandinelli	IDS Ingegneria Dei Sistemi S.p.A., Via Enrica Calabresi 24 - 56121 Pisa	Italy
4	Felipe Vico-Bondía	Universidad Politécnica de Valencia, Spain	Spain
5	Siniša Antonijević,	University of Split, PMF, Department of Polytechnics, Teslina 12, Split, 21000	Croatia
6	Dragan Poljak	University of Split, FESB, Department of Electronics, R. Boškovića 32, Split, 21000	Croatia
7	Silvestar Šesnić	University of Split, FESB, Department of Electronics, R. Boškovića 32, Split, 21000	Croatia
8	Bartosz Bieda,	Wroclaw University of Technology, Faculty of Electronics, Wroclaw	Poland
9	Piotr Slobodzian	Wroclaw University of Technology, Faculty of Electronics, Wroclaw	Poland

10	Diego Martinez Solís	University of Vigo	Spain
11	Dubravko Babić	University of Zagreb, Faculty of Electrical Engineering and Computing, Applied Optics Laboratory, Zagreb	Croatia
12	Tin Komljenović	University of Zagreb, Faculty of Electrical Engineering and Computing, Applied Optics Laboratory, Zagreb	Croatia
13	Angelo Freni	Department of Information Engineering, University of Florence, Via di S. Marta 3, 50139 Florene	Italy
14	Guido Valerio	Université de Rennes 1, Institut d'Electronique et de Télécommunications de Rennes, UMR CNRS 6164, 35042 Rennes	France
15	Ladislau Matekovits	Politecnico di Torino, Dipartimento di Elettronica e Telecomunicazioni	Italy
16	Alex Nosich	Institute of Radiophysics and Electronics NASU, Laboratory of Micro and Nano Optics, Kharkiv 61085	Ukranie
17	Jens Eberhard	CST-Computer Simulation Technology AG, Bad Nauheimer Strasse 19, 64289 Darmstadt	Germany
18	Ulf Kraemer	CST-Computer Simulation Technology AG, Bad Nauheimer Strasse 19, 64289 Darmstadt	Germany
19	Marko Bosiljevac	University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, Zagreb, 10000	Croatia
20	Mladen Vukomanović	University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, Zagreb, 10000	Croatia
21	Zvonimir Sipus	University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, Zagreb, 10000	Croatia