Application

2015-03-31

2015-04961	Stumpf, Martin	NT-14

Information about applicant

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Information about application

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Participants

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Descriptive data

Project info

Project title (Swedish)*

Tillämpad rums-tids reciprocitet inom elektromagnetiska beräkningar och kompatibilitet

Project title (English)*

Applications of Space-Time Reciprocity in Computational Electromagnetic Compatibility

Abstract (English)*

The ever increasing integration of electronic digital systems with their still decreasing immunity levels urgently call for the development of purely time-domain (TD) approaches capable of assessing potential transient electromagnetic interference (EMI) sources and thus securing such systems' smooth co-existence and safe operation. This is exactly the main motivation of the proposed project that aims at constructing fundamentally novel, TD reciprocity-based computational approaches concerning EMI, susceptibility and power/signal-integrity (SI/PI) analysis.

The concept of reciprocity in electromagnetic (EM) theory can be understood as a result of structuralism, i.e., rather than studying the objects themselves one focuses on their mutual relations or interactions. The study of EM interactions is also the main subject of electromagnetic compatibility (EMC). Now realizing the fact that present-day EMC still mostly leans on the frequency-domain paradigm and that any physical phenomena (including transient electromagnetic interference radiated by modern digital communication devices) manifest themselves in space-time only, the time-domain EM reciprocity theorems seem to be the most natural tools to lay down the foundations of space-time EMC.

Operation of modern, digital (broad-band) communication devices and accompanied radiated EMI are inherently of the TD nature. The vast majority of EMI/EMC techniques, however, are as yet defined in the frequency domain. Unavoidably, their application to real-life (space-time) problems is not directly relevant and requires the use of an inverse (fast) Fourier transformation. Besides the fact that this way involves (mostly time-consuming) repeated calls of the computational procedure for a large number of frequencies, it in addition does not account for the universal property of causality and it cannot plausibly handle pulsed signals whose values show discontinuities in their function values or/and time derivatives.

A natural way out of these difficulties is to construct EMI/EMC computational methods entirely in space-time. As to the widespread contour-integral method (CIM), this idea has been initiated by the principal investigator who has shown that the reciprocity theorems may lead to novel CIM-based formulations in the time-domain. The purpose of the project is hence to take the advantage of the gained unique expertise and introduce, through systematic applications of the TD reciprocity theorems, new space-time concepts in (computational) EMC. More specifically, this includes the construction of (a) purely space-time interaction quantities allowing for causality-preserving (and thus physically correct) assessment of the interaction of pulsed EMI sources with adjoining physical (e.g. biological) objects; (b) fundamentally novel space-time reciprocity-based computational approaches for the efficient tackling of EMI, susceptibility and SI/PI issues.

Popular scientific description (Swedish)*

Den ständigt ökande integrationen av elektroniska digitala system i kombination med alltför störningskänsliga elektronikenheter kräver en utveckling av renodlade tidsdomän (TD) baserade metoder som har förmåga att detektera transienta elektromagnetiska störningar (eng. electromagnetic interference, EMI) och därigenom säkra enhetens funktion och samexistens med andra system (eng. electromagnetic compatibility, EMC). Detta problem utgör grundmotivationen för detta forskningsprojekt som syftar till att utveckla nya reciprocitetsbaserade beräkningsmetoder direkt i tidsdomän vad avser EMI, EMC, känslighet och effekt/signalintegritet för sådana system.

Reciprocitetsbegreppet inom elektromagnetisk (EM) teori kan förstås som ett resultat av strukturalism, dvs istället för att studera objekten själva så fokuserar man på deras ömsesidiga relationer och interaktioner. Studiet av elektromagnetisk interaktion är också ett centralt begrepp inom elektromagnetisk kompatibilitet (EMC). Om man beaktar att dagens EMC-metoder fortfarande lutar sig på en frekvensdomäns-paradigm samt att alla fysikaliska fenomen (inklusive transienta elektromagnetiska störningar från modern digital kommunikationsutrustning) manifesterar sig endast i rums-tid, så förefaller EM reciprocitetsteoremen formulerade i tidsdomän vara de mest naturliga verktygen att använda för rums-tids EMC.

Moderna, digitala bredbands-kommunikationssystem och elektronikenheter är till sin grundläggande natur TD-baserade. Trots detta faktum är den stora majoriteten av EMI/EMC metoder fortfarande definierade i frekvensdomän. Detta gör att resultaten av dessa metoder inte är direkt användbara utan kräver normalt en invers (snabb) Fourier transformering för att kunna utnyttjas i ett rums-tid sammanhang. Förutom att detta angreppssätt innebär (tidskrävande) upprepade anrop av en särskild beräkningsprocedur för ett stort antal frekvenser, så är dessa metoder oftast inte fullt ut tids-kausala. Tids-kausalitet är en av de mest grundläggande fysikaliska egenskaperna hos ett verkligt system och innebär att en utsignal (verkan) inte kan föregå en insignal (orsak). Frekvensdomänsmetoder som inte fullt ut utnyttjar tids-kausalitet kan därför inte på ett korrekt och noggrant sätt hantera transienta och diskontinuerliga tidsförlopp.

Ett naturligt sätt att angripa dessa problem är att utveckla beräkningsmetoder för EMI/EMC direkt i tidsdomän. Genom att använda en konturintegralmetod har den huvudsökande i detta projekt redan visat att reciprocitetsteoremen kan användas för att formulera nya beräkningstekniker i tidsdomän. Syftet med projektet är att utnyttja våra unika kunskaper och erfarenheter inom detta område för att genomföra en systematisk utredning och utveckling av reciprocitetsteoremen i tidsdomän samt dess rums-tids tillämpningar inom elektromagnetiska beräkningar och EMC. Mera specifikt omfattar detta en konstruktion och en beskrivning av (a) kausalitetsbevarande (och därmed fysikaliskt korrekt) rums-tids-interaktion mellan pulsade EMI-källor med tillhörande (t.ex. biologiska) objekt; (b) grundläggande nya rums-tids-reciprocitetsbaserade beräkningsmetoder för effektiv hantering av EMI, EMC, känslighet och andra signal-integritetsrelaterade problem.

Project period

Number of project years*

2

Calculated project time*

2016-01-01 - 2017-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*	2. Teknik > 202. Elektroteknik och elektronik > 20205. Signalbehandling
	1. Naturvetenskap > 103. Fysik > 10399. Annan fysik
	2. Teknik > 202. Elektroteknik och elektronik > 20299. Annan elektroteknik och elektronik

Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Time-Domain Electromagnetic Compatibility

Keyword 2*

Transient Electromagnetic Interference

Keyword 3*

Space-Time Reciprocity Theorems

Keyword 4

Signal and Power Integrity

Keyword 5

Time-Domain Integral Equation Techniques

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

Inga etiska överväganden är aktuella i denna ansökan.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Applications of Space-Time Reciprocity in Computational Electromagnetic Compatibility

1 Purpose and aims

The ever increasing integration of electronic digital systems with their still decreasing immunity levels urgently call for the development of purely time-domain (TD) approaches capable of assessing potential transient electromagnetic interference (EMI) sources and thus securing such systems' smooth co-existence and safe operation. This is exactly the main motivation of the proposed project that aims at constructing fundamentally novel, TD reciprocity-based computational approaches concerning EMI, susceptibility and power/signal-Integrity (SI/PI) analysis.

The concept of reciprocity in electromagnetic (EM) theory can be understood as a result of structuralism, i.e., rather than studying the objects themselves one focuses on their mutual relations or interactions. The study of EM interactions is also the main subject of electromagnetic compatibility (EMC). Now, realizing the fact that present-day EMC still mostly leans on the frequency-domain paradigm and that any physical phenomena (including transient electromagnetic interference radiated by modern digital communication devices) manifest themselves in space-time only, the time-domain EM reciprocity theorems seem to be the most natural tools to lay down the foundations of space-time EMC.

Operation of modern, digital (broad-band) communication devices and accompanied radiated EMI are inherently of the TD nature. The vast majority of EMI/EMC techniques, however, are as yet defined in the frequency domain (FD). Unavoidably, their application to real-life (space-time) problems is not directly relevant and requires the use of an inverse (fast) Fourier transformation. Besides the fact that this way involves (mostly time-consuming) repeated calls of the computational procedure for a large number of frequencies, it in addition does not account for the universal property of causality and it cannot plausibly handle pulsed signals whose values show discontinuities in their function values or/and time derivatives.

A natural way out of these difficulties is to construct EMI/EMC computational methods entirely in space-time. As to the widespread contour-integral method (CIM), this idea has been initiated by the principal investigator (PI) who has shown that the reciprocity theorems may lead to novel CIM-based formulations in the time domain.

The purpose of the project is to take advantage of the gained unique expertise and introduce, through systematic applications of the reciprocity theorems, new *space-time* concepts in (computational) EMC. More specifically, this includes the construction of

1. purely *space-time interaction* quantities allowing for causality-preserving (and thus physically correct) assessment of the interaction of *pulsed* EMI sources with adjoining physical (e.g. biological) objects;
2. fundamentally novel *space-time reciprocity-based* computational approaches for the efficient tackling of EMI, susceptibility and SI/PI issues.

More details about the project aims are specified below.

2 Survey of the field

The great bulk of electromagnetic compatibility (EMC) theory leans heavily on the FD paradigm (e.g. [1, Sec. III]). Along with the emergence of high-speed digital communication systems, however, there is a demand for purely TD, causality-preserving concepts of pulsed-field interaction analysis.

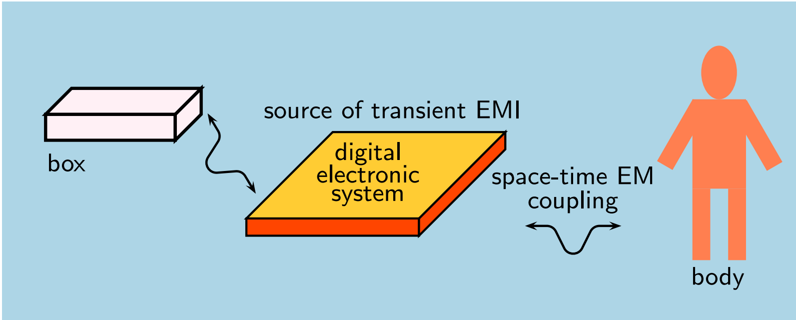

Figure 1: A source of transient EMI and its space-time EM coupling to adjoining objects.

The TD reciprocity theorems can be applied to analyze pulsed systems themselves as well as their EM interaction with adjoining objects (see Fig. 1). In this context, the TD reciprocity theorem of the time-convolution type is mostly useful for describing TD mutual coupling phenomena [2] while its time-correlation counterpart finds its applications in EM energy-based considerations [3]. Such reciprocity-based formulations are not useful only in quantifying radiated electromagnetic emissions and their consequences with respect to electronic systems, but may also yield important outcomes in the assessments of the impact of *pulsed* electromagnetic fields on biological objects [4]. In this respect, the vast majority of recent studies handle the interaction via brute-force numerical techniques, which can hardly produce deep physical insights into the problem (see e.g. [5, 6]).

The sound theory for EM-wave coupling to relatively simple transmission lines does exist [1, 7, 8]. Its direct application to systems of higher complexity such as met in practice, however, is not possible. Accordingly, the previous works on the subject use either brute-force numerical methods [9, 10] or approximate (FD) models [11, 12] to solve the problem. The numerical methods that fall in the first category, again, do mostly provide superficial physical insights only, while the second group, based on the 'fundamental-mode approximation' and similar concepts, does not comply with the universal property of causality making them useless for TD modeling.

Parallel-plane structures constitute the basic building block of multilayered printed circuit boards (PCBs) and hence of many digital electronic systems (see Fig. 2). In them, the generic power-ground structure is represented by a pair of power and ground (mutually parallel) conducting planes that serve for the power supply of connected digital integrated circuits (ICs). The fast (non-ideal) switching of ICs between their logical high and low states subsequently gives rise to the switching noise that, when propagates throughout a PCB, may cause serious SI/PI issues as well as radiated EMI. The main goal of a PCB design is hence to minimize the noise propagation to a level that enables proper circuits' operation and suppresses radiated emission below the EMI regulatory requirements [13]. As the engineering design procedure can be in principle viewed as a multi-objective optimization problem requiring multiple analysis of PCBs for varying parameters, an efficient computational tool for this purposes is of crucial practical importance.

EMC problems on PCBs can be, in principle, analyzed with the aid of full-wave methods such as the finite-difference TD technique [14], the partial element equivalent circuit technique [15] and others (see [16] for references therein). Their computational demands, however, grow rapidly with the problem complexity and its relative electrical size. It is hence natural to take advantage of the characteristic geometrical features of practically used planar circuits and develop dedicated numerical approaches capable of reducing the high computational costs of complex problems met in practice. This strategy was followed in the multilayered finite-difference method [17], the finite-difference-based equivalent-circuit approach [18] and the FD contour integral method (CIM) [19, 20], for example. Among computational methods falling in this category, the one-dimensional (contour) discretization scheme makes the CIM-based formulation superior with

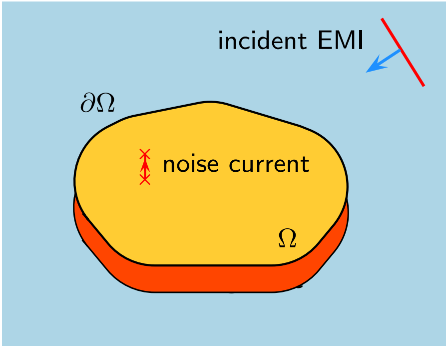

Figure 2: An arbitrarily shaped double-plane structure activated by a current noise source and an incident wave.

regard to the requirement of computational resources. As a consequence, CIM-based techniques may solve involved EMC problems of high complexity that is far beyond the standard, direct-discretization computational techniques.

The classical CIM pioneered by Okoshi is a widespread numerical technique for analyzing arbitrary-shaped double-plane circuitry in the FD [21]. Thanks to its high efficiency it has recently found a wealth of applications especially in the field of EMC for complex SI/PI, EMI and susceptibility analysis on PCBs [20, 22, 23]. High-speed (digital) signal transmissions on a PCB and related EMC issues are inherently of the TD nature. The standard CIM is, however, a purely FD technique and its applications to TD problems thus necessitate the application of an inverse (fast) Fourier transformation. This way, obviously, requires repeated calls of the computational procedure for a large number of frequencies. On top of the fact that this procedure does not account for the universal property of causality, it cannot plausibly handle pulsed signals whose values show discontinuities in their function values or/and time derivatives. In addition, the standard CIM in general leads, at each frequency point, to a dense non-symmetric system of linear algebraic equations (see [21, Sec. 3.5]) making the repeated calculations computationally demanding. A natural way out of these difficulties is to construct a contour-integral technique entirely in the TD. This idea has been initiated about four decades after the seminal paper of Okoshi by the PI who has constructed a novel computational technique entitled the time-domain contour integral method (TD-CIM) [24].

3 Project description

The proposed project aims at introducing novel computational concepts in EMC through the systematic use of space-time reciprocity. Details of this are given below.

3.1 Scientific approach

A convenient starting point for constructing novel TD EMC computational approaches is the TD reciprocity theorem in its most general form [25, Chap. 28]. A reciprocity theorem interrelates two admissible states of wavefields that may exist in one and the same time-invariant domain in space, where they are associated with their own field, source and material states (see Fig. 3). Applications of reciprocity theorems is largely a matter of ingenuity, which makes them the most intriguing relations in physics that have attracted attention of many prominent physicists such as von Helmholtz, Rayleigh or Lorentz. A pertinent description in this respect is given by Achenbach [26, Sec. 1.1]: "*Reciprocity is a good thing. Something is given and something else, equally or more valuable, is returned.*". Concerning the TD aspects such as the property of causality, it is very important to notice that one can distinguish between the reciprocity theorem of the time-convolution and time-correlation type. Being aware of the fact that the reciprocity theorems encompass all known formulations of direct/inverse source and scattering problems, they can serve our purposes very well.

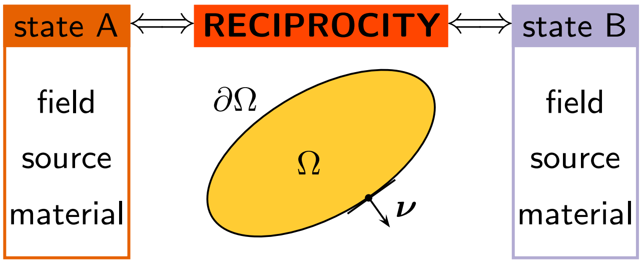

Figure 3: The generic form of a reciprocity theorem.

3.2 Implementation

The proposed project will start with the research into (global-type) reciprocity-based formulations concerning space-time interactions and pulsed radiated EMC/EMI/susceptibility analysis of generic structures. Simultaneously, the reciprocity-based formulations will be implemented and tested with regard to their computational requirements, efficiency and precision.

As to the relevant integral-equation techniques, the corresponding numerical procedure requires a spatial discretization of a boundary surface. This, besides the drastic reduction of required computational resources, considerably simplifies the computer programming of codes. As a consequence, the following 'post-processing' steps such as the evaluation of time-domain radiation characteristics are relatively straightforward as well. As is well-known, the latter generally follows from the 'slant-stack' transformation of equivalent source densities occupying either volume or surface of a scatterer [27]. Now, taking into the account the one-dimensional support of radiating magnetic currents in the CIM-based formulation, one can expect high efficiency in the numerical evaluation of secondary circuit's parameters as well. If the entire procedure is carried out in the TD, the relevant FD parameters in a wide band of frequencies can be obviously extracted in a single run, implying the high efficiency.

An integral part of the project is the competitive benchmarking of the developed computational tool with respect to the standardly used numerical approaches. As a spin-off of this step, that is however of high importance, is the detailed validation of outputs. Despite the fact that there is presently no integral-equation time-domain computational tool available on the market, a brute-force direct-discretization approach such as the finite-difference time-domain technique is, at the prize of relatively high computational requirements, applicable.

All the developed TD, reciprocity-based EMC solutions will be implemented in the Matlab® environment. Matlab® is essentially a high-level programming language that thanks to its versatility has become popular in academia as well as industry. Since Matlab® enables to write a modular computational code furnished with a graphical user interface, it will serve our purpose very well. A successful completion of the project will hence lead to the entirely unique, time-domain reciprocity-based methodologies including a TD-CIM based computational tool for efficient solving a wide set of EMC problems on PCBs. Perspective applications of the latter can be found in the EMC research as well as in the educational process. Taking into the account that such a tool is presently missing on the market, the final product might have a high commercial value.

3.3 Participants and organization

The PI is presently an assistant professor at the Brno University of Technology, Czech Republic. His research interests cover the broad field of the mathematical physics of wave phenomena, in particular, the development of relevant time-domain computational methods (see more details

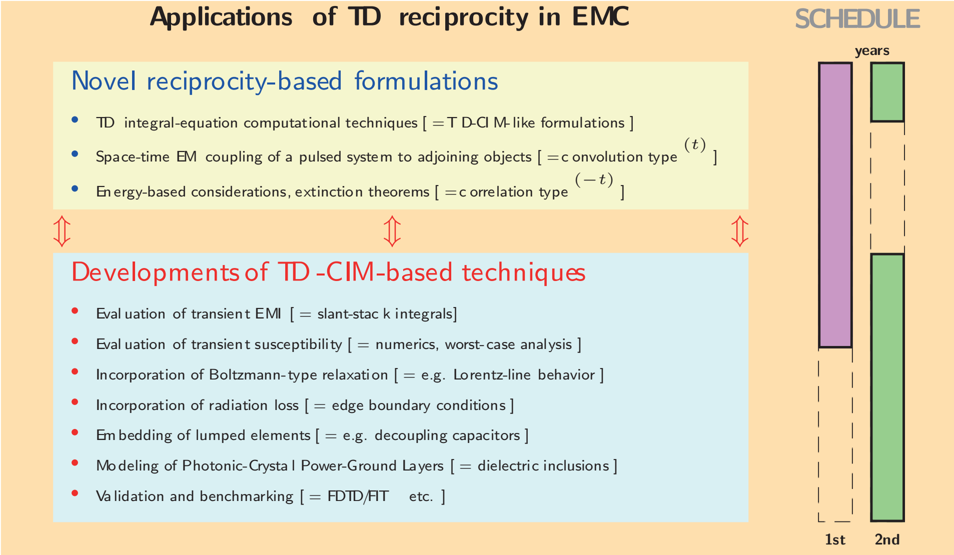

Figure 4: The detailed research program with its time plan.

at http://www.martin-stumpf.com). In order to enhance his fruitful research cooperation with Professors Sven Nordebo and Börje Nilsson, this project proposal is being submitted on behalf of the Linnæus University (LNU) in Växjö, namely, of the group of *Waves and Signals* (see http://lnu.se/ws). In case the project is positively evaluated, the PI will be hired by the LNU as a guest researcher and become a member of the group. As to the proposed project itself, the research will take the advantage of the research experiences of Professor Sven Nordebo who also has the relevant academic and industrial contacts in Sweden, and who will be a collaborator in this project.

3.4 Time-schedule

Given the expertise already built-up by the PI, the research project on novel space-time computational concepts in EMC is estimated to be feasible within a 2-year period. The detailed research program with its time plan are summarized in Fig. 4. Here, for each of the particular research topics (as briefly described in the application), a time slot in the research period is clearly assigned. In Fig. 4, the red ⇳s denote the transition phase between the purely theoretical and implementation periods. Owing to the close interconnections between the proposed research topics, the research periods in the two years naturally overlap each other.

4 Significance

With still increasing bit-rates of digital signals being transfered on high-speed interconnections, the electromagnetic radiation from and the EM relaxation or/and susceptibility behavior of interconnect structures have become issues of paramount importance. As to radiated EMI from PCBs, for instance, the problem is traditionally tackled in the FD (see e.g. [20]). As this seems to be a strange way to handle physics (that manifests itself in space-time only, i.e. in the TD) the present project will introduce novel TD approaches that avoid the accompanying issues. Such purely-time, causality preserving closed-form models that are capable of providing physical insights into the action of pulsed EM fields are presently missing in the literature on the subject. Another interesting question in this respect is TD modeling of radiation losses. As the traditional (FD) approaches [28, Sec. 14.2.2] can hardly serve the purpose in the TD, the incorporation of radiation losses in the TD-CIM framework may reveal novel avenues for TD loss modeling [29].

As yet, time-domain boundary integral equation techniques have been formulated via the reciprocity theorem of the time-convolution type (e.g. [24]). The question whether the application of the time-correlation reciprocity leads to computationally favorable formulations thus naturally turns up. Research into novel (time-correlation) reciprocity-based formulations and their properties and algorithm developments will hence be carried out in the proposed project. A successful completion of this task may have a significant impact on computational electromagnetics as a whole.

Efficient evaluation of the edge magnetic-current space-time distribution is not important only for EMI analysis when a PCB acts as the source, but also reciprocally, for its susceptibility analysis. It is anticipated that the reciprocity theorem of the time-convolution type together with the TD-CIM can serve as a powerful tool for time-domain susceptibility analysis of arbitrarily-shaped double-plane structures. On top of this, for canonical structures whose time-domain Green's function is known in the closed form [30], analytical worst-case estimates for evaluating PCB's vulnerability might be derivable. Such results are expected to play an illuminating role in the definition of novel *time-domain* (rather than standard FD) EMC standards.

An issue frequently encountered in EMC and antenna engineering applications is the proper embedding of lumped circuit elements to a double-plane structure. Examples in this respect are the decoupling capacitors, that are useful in preventing from the power integrity issues on high-speed PCBs [13], or properly located resistive loads supporting a broadband circular-polarization antenna radiation pattern [31]. The inclusion of additional circuit elements within the TD-CIM framework is hence a vital objective of the present project. Here, the fundamental questions as to embedded elements' linearity and passivity are expected to be of high importance regarding algorithms' convergence and stability properties. Moreover, the proper matching of *temporal* testing functions to embedded element's scattering properties must be carefully addressed.

An alternative way that eliminates simultaneously switching-noise phenomena and accompanying EMI makes use of high-dielectric, cylindrical inclusions in a homogeneous substrate, known as a photonic crystal power-ground layer (PCPL) [32]. The PCPL has been successfully implemented in the standard FD CIM [33] using the segmentation method [21, Sec. 5]. TD analysis via the reciprocity-based TD-CIM would be possible as well. In this effort, again, a special care has to be paid to temporal aspects of the relevant global-interaction quantity. As the PCPL-based noise mitigation can substitute (inefficient) decoupling capacitors at the gigahertz range [33], the research into the efficient TD modeling of arbitrarily-shaped dielectric inclusions in the TD-CIM framework will contribute to a more efficient design of less (electromagnetically) interfering and susceptible digital electronic systems.

5 Preliminary results

As has been recently recognized by the PI [24], the reciprocity theorem of the time-convolution type leads to an entirely new time-domain numerical technique, the so-called time-domain contour-integral method (TD-CIM). Basically, the TD-CIM can be formulated from the reciprocity theorem and interpreted as the 'weak' formulation corresponding to the initial-boundary value problem that directly arises from Maxwell's equations. This 'weak' TD-CIM formulation is represented by a global interaction quantity of the second kind that has to be, in general, solved by a numerical means. The proposed contour-integral formulation leads to (spatial) dimensionality reduction from 3 to 1, which implies promisingly high efficiency of a properly implemented TD-CIM-based computational tool.

The TD-CIM may be formulated via the time-domain reciprocity theorem applied to a bounded domain Ω representing the top conducting surface of a double-plate structure and to two electromagnetic field states, say the actual field state (state A) and a properly chosen (auxiliary) testing state (state B). In this respect, only the reciprocity theorem of the time-convolution type has been applied so far [24].

With still increasing clock-rates on high-speed PCBs, the incorporation of relaxation and dissipation mechanisms becomes a must. While the inclusion of relaxation behavior in the standard differential approaches is more or less straightforward, the situation is very different for time-domain integral-equation techniques. In them, any change in material's time-domain response changes the kernel of a global interaction quantity and so its numerical handling. A possible inclusion of the conduction-loss and Debye-like relaxation models in the TD-CIM has been recently proposed by the PI [34]. As was experimentally shown (e.g. [35]), however, the Debye absorption model may not be sufficient for describing practically used materials at high frequencies. In such a case, one has to resort to higher-order relaxation models whose efficient incorporation in the TD-CIM is therefore of a major importance in the project. It is noted in this respect that the research into this problem may potentially reveal the need of new techniques of a numerical Laplace-transform inversion.

As the recent results reveal [36, Sec. III], the TD-CIM is very promising for the efficient evaluation of time-domain radiation characteristics of arbitrarily-shaped double-plane radiators. It is remarkable in this context that the pulsed-field response in the far-field region can be obtained through the property of self-reciprocity [36, Sec. IV.B] also applied to susceptibility analysis of PCBs.

Yet another reciprocity-based application of the TD-CIM has been recently proposed in [2]. The latter deals with a closed-form description of time-domain mutual coupling phenomena between two arbitrarily-shaped power-ground structures that facilitates its highly efficient evaluation. This development is based on proper applications of the time-convolution reciprocity theorem combined with the Kirchhoff integral representations of the disturbing magnetic field along the receiving circuit (a victim). In this respect, a study into the optimization of mutual-coupling strength between two planar structures will be carried out.

6 International and national collaboration

The PI is actively involved in the research on time-domain wave field modeling at an international level. As can be exemplified by numerous collective publications, his collaborators are the top researchers in the field. Among others, he had the opportunity to learn the Cagniard-DeHoop method first-hand from Professor Adrianus T. De Hoop of the Delft University of Technology, who served as his PhD (co)-supervisor. Recently, the PI enjoys the close co-operation with the group of *Waves and Signals* at the Linnæus University in Växjö, on behalf of which the present project proposal is being submitted. On a long-term basis, the PI also co-operates with the group of Professor Guy A. E. Vandenbosch of the ESAT-TELEMIC division at KU Leuven, where he spent a year and a half as a Postdoctoral Research Fellow.

In the field of EMC, the PI is a member of the management committee of the COST IC1407 '*Advanced characterization and classification of radiated emissions in densely integrated technologies*' (ACCOST) and of the *IEEE EMC Society.*

7 Other grants

This 2-year research application also complements another research application from the rector of the Linnæus University regarding a 1-year international visiting professorship (2014-2015) for the PI and which has recently been submitted to The Knowledge Foundation (KKS) within their program for *strategic knowledge enhancement 2014.* In the KKS-application, too, the research in the field of wave modeling is proposed in order to support the scientific co-operation of the visiting professor and the group of *Waves and Signals* (see http://lnu.se/ws) of the Linnæus University with their academia and industry partners.

8 Independent line of research

Dr. Martin Štumpf will act as the principal investigator (PI) of the project. His expertise in time-domain wavefield modeling will be supplemented with the research experiences of Professor Sven Nordebo who will be a collaborator in this project. Thanks to this synergy, a successful completion of the project is estimated to be feasible within the proposed period.

The PI will further take the advantage of a diverse research environment of the *International Center for Mathematical Modeling* (ICMM), in which a very unique mixture of dedicated scientists is involved. This includes prominent experts in wavefield physics, signal processing, applied mathematics as well as pure mathematics.

References

[1] F. M. Tesche, M. V. Ianoz, and T. Karlsson, *EMC Analysis Methods and Computational Models*. New York, NY: John Wiley & Sons, Inc., 1997.

[2] M. Štumpf, "Time-domain mutual coupling between power-ground structures," in *IEEE Int. Symp. EMC*, Raleigh, NC, USA, August 2014, pp. 240–243.

[3] M. Štumpf and I. E. Lager, "The time-domain optical theorem in antenna theory," *IEEE Antennas and Wireless Propagation Letters*, 2015 [available via the IEEE Xplore].

[4] A. Christ, M. Douglas, J. Nadakuduti, and N. Kuster, "Assessing human exposure to electromagnetic fields from wireless power transmission systems," *Proceedings of IEEE*, vol. 101, no. 6, pp. 1482–1493, June 2013.

[5] Y. Yoshino, S. Igo, M. Katsuragi, and M. Taki, "Assessment of human exposure to electromagnetic field from an intra-body communication device using intermediate-frequency electric field," in *Proc. 2012 Int. Symp. EMC Europe*, Rome, Italy, September 2012, pp. 1–4.

[6] H.-J. Song, H. Shin, H.-B. Lee, J.-H. Yoon, and J.-K. Byun, "Induced current calculation in detailed 3-D adult and child model for the wireless power transfer frequency range," *IEEE Transactions on Magnetics*, vol. 50, no. 2, p. 7025804, February 2014.

[7] H. L. S. M. Leone, "On the coupling of an external electromagnetic field to a printed circuit board trace," *IEEE Transactions on Electromagnetic Compatibility*, vol. 41, no. 4, pp. 418–424, November 1999.

[8] F. Rachidi, "A review of field-to-transmission line coupling models with special emphasis to lightning-induced voltages on overhead lines," *IEEE Transactions on Electromagnetic Compatibility*, vol. 54, no. 4, pp. 898–911, August 2012.

[9] L. Page, M. Jouvet, and B. Jecko, "A new method for mutual coupling between antennas associating FDTD with time domain integral expression of electromagnetic fields," in *Digest of 1996 Antennas and Propag. Soc. Int. Symp.*, vol. 2, Baltimore, MD, USA, July 1996, pp. 1288–1291.

[10] D. A. White and M. Stowell, "Full-wave simulation of electromagnetic coupling effects in RF and mixed-signal ICs using a time-domain finite-element method," *IEEE Transactions on Microwave Theory and Techniques*, vol. 52, no. 5, pp. 1404–1413, May 2004.

[11] M. Malkomes, "Mutual coupling between microstrip patch antennas," *Electronic Letters*, vol. 18, no. 12, pp. 520–522, June 1982.

[12] E. Penard and J.-P. Daniel, "Mutual coupling between microstrip patch antennas," *Electronic Letters*, vol. 18, no. 14, pp. 605–607, July 1982.

[13] J. L. Knighten, B. Archambeault, J. Fan, G. Selli, S. Connor, and J. L. Drewniak, "PDN design strategies: I. ceramic SMT decoupling capacitors – what values should I choose?" *IEEE EMC Society Newsletter*, no. 207, pp. 54–64, Fall 2005.

[14] C. Schuster and W. Fichtner, "Parasitic modes on printed circuit boards and their effects on EMC and signal integrity," *IEEE Transactions on Electromagnetic Compatibility*, vol. 43, no. 4, pp. 416–425, November 2001.

[15] A. E. Ruehli, G. Antonini, and L. J. Jiang, "Skin-effect loss models for time- and frequency-domain PEEC solver," *Proceedings of the IEEE*, vol. 101, no. 2, pp. 451–472, February 2013.

[16] B. Archambeault, C. Brench, and S. Connor, "Review of printed-circuit-board level EMI/EMC issues and tools," *IEEE Transactions on Electromagnetic Compatibility*, vol. 52, no. 2, pp. 455–461, May 2010.

[17] A. E. Engin, K. Bharath, and M. Swaminathan, "Multilayered finite-difference method (MFDM) for modeling of package and printed circuit board planes," *IEEE Transactions on Electromagnetic Compatibility*, vol. 49, no. 2, pp. 441–447, May 2007.

[18] M. Leone, M. Friedrich, and A. Mantzke, "Efficient broadband circuit-modeling approach for parallel-plane structures of arbitrary shape," *IEEE Transactions on Electromagnetic Compatibility*, vol. 55, no. 5, pp. 941–948, October 2013.

[19] T. Okoshi and T. Miyoshi, "The planar circuit – an approach to microwave integrated circuitry," *IEEE Transactions on Microwave Theory and Techniques*, vol. 20, no. 4, pp. 887–892, April 1972.

[20] M. Štumpf and M. Leone, "Efficient 2-D integral equation approach for the analysis of power bus structures with arbitrary shape," *IEEE Transactions on Electromagnetic Compatibility*, vol. 51, no. 1, pp. 38–45, Feb. 2009.

[21] T. Okoshi, *Planar Circuits for Microwaves and Lightwaves*, ser. Springer Series in Electrophysics. Berlin: Springer-Verlag, 1985.

[22] X. Duan, R. Rimolo-Donadio, H.-D. Brüns, and C. Schuster, "A combined method for fast analysis of signal propagation, ground noise, and radiated emission of multilayer printed circuit boards," *IEEE Transactions on Electromagnetic Compatibility*, vol. 52, no. 2, pp. 487–495, May 2010.

[23] H. Zhao, J. H. E.-X. Liu, and E.-P. Li, "Fast contour integral equation method for wideband power integrity analysis," *IEEE Transactions on Components, Packaging and Manufacturing Technology*, vol. 4, no. 8, pp. 1317–1324, August 2014.

[24] M. Štumpf, "The time-domain contour integral method – an approach to the analysis of double-plane circuits," *IEEE Transactions on Electromagnetic Compatibility*, vol. 56, no. 2, pp. 367–374, April 2014.

[25] A. T. de Hoop, *Handbook of Radiation and Scattering of Waves.* London, UK: Academic Press, 1995.

[26] J. D. Achenbach, *Reciprocity in Elastodynamics.* Cambridge, UK: Cambridge University Press, 2003.

[27] A. Shlivinski, E. Heyman, and R. Kastner, "Antenna characterization in the time domain," *IEEE Transactions on Antennas and Propagation*, vol. 45, no. 7, pp. 1140–1149, July 1997.

[28] C. A. Balanis, *Antenna theory, 3rd Ed.* Hoboken, NJ: John Wiley & Sons, Inc., 2005.

[29] F. E. Gardiol, "Open question to time-domain experts," *IEEE Antennas and Propagation Society Newsletter*, vol. 30, no. 5, p. 48, October 1988.

[30] M. Štumpf, "Time-domain analysis of rectangular power-ground structures with relaxation," *IEEE Transactions on Electromagnetic Compatibility*, vol. 56, no. 5, pp. 1095–1102, October 2014.

[31] J. Y. Wu, C. Y. Huang, and K. L. Wong, "Compact broadband circularly polarized square microstrip antenna," *Microwave and Optical Technology Letters*, vol. 21, no. 6, pp. 423–425, June 1999.

[32] S.-T. C. T.-L. Wu, "A photonic crystal power/ground layer for eliminating simultaneously switching noise in high-speed circuit," *IEEE Transactions on Microwave Theory and Techniques*, vol. 54, no. 8, pp. 3398–3406, August 2006.

[33] J. B. Preibisch, X. Duan, and C. Schuster, "An efficient analysis of power/ground planes with inhomogeneous substrates using the contour integral method," *IEEE Transactions on Electromagnetic Compatibility*, vol. 56, no. 4, pp. 980–989, August 2014.

[34] M. Štumpf, "Analysis of dispersive power-ground structures using the time-domain contour integral method," *IEEE Transactions on Electromagnetic Compatibility*, 2015 [available via the IEEE Xplore].

[35] M. Y. Koledintseva, J. L. Drewniak, D. J. Pommerenke, G. Antonini, A. Orlandi, and K. N. Rozanov, "Wide-band Lorentzian media in the FDTD algorithm," *IEEE Transactions on Electromagnetic Compatibility*, vol. 47, no. 2, pp. 392–399, May 2005.

[36] M. Štumpf, "Pulsed EM field radiation, mutual coupling and reciprocity of thin planar antennas," *IEEE Transactions on Antennas and Propagation*, vol. 62, no. 8, pp. 3943–3950, August 2014.

Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Martin Stumpf	70
2	Participating researcher	Sven Nordebo	20

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	Total
1	Applicant	Martin Stumpf	70	728,502	728,502	1,457,004
2	Participating researcher	Sven Nordebo	20	237,662	237,662	475,324
	Total			966,164	966,164	1,932,328

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

Type of premises	2016	2017

Running Costs

	Running Cost	Description	2016	2017	Total
1	Resor	konferenser, mm	50,000	50,000	100,000
2	Publikationskostnader, mm		10,000	10,000	20,000
3	Mjukvara	CST MW Studio, COMSOL.	50,000	50,000	100,000
	Total		110,000	110,000	220,000

Depreciation costs

Depreciation cost	Description	2016	2017

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	Total, applied	Other costs	Total cost
Salaries including social fees	966,164	966,164	1,932,328		1,932,328
Running costs	110,000	110,000	220,000		220,000
Depreciation costs			0		0
Premises			0		0
Subtotal	1,076,164	1,076,164	2,152,328	0	2,152,328
Indirect costs	462,792	462,792	925,584		925,584
Total project cost	1,538,956	1,538,956	3,077,912	0	3,077,912

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

Vi söker forskningsmedel för projektledaren Martin Stumpf, 70 % av heltid.
Vi söker forskningsmedel för Sven Nordebo, 20 % av heltid.

Vi söker forskningsmedel för att anställa Martin Stumpf som gästprofessor/forskare vid LNU på 70 % av heltid.
Resterande 30 % av Martin Stumpfs lön kommer att medfinansieras av fakulteten samt med undervisning.

Kostnader för resor avser i huvudsak konferensresor med tillhörande kostnader, men också andra projektrelaterade resor.
Publikationskostnader, litteratur, mm. är en löpande kostnad för vår forskningsverksamhet.
Vi har också behov av relativt dyra programvarulicenser till CST Microwave Studio samt COMSOL.

Rektor för Linnéuniversitetet har ansökt medel via KK-stiftelselsens utlysning om strategisk kompetensförstärkning
att anställa Martin Stumpf som gästprofessor under 1 år (2015-2016). Skulle KKS-ansökan falla ut positivt vill vi vid ett ev. positivt
utfall av även den föreliggande ansökan använda vetenskapsrådets finansiering som ett komplement och anställa
Martin Stumpf som gästprofessor på ett längre mandat, dvs 2-3 år.

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

	Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	Total
1	KK-stiftelsen	Stephen Wang/Sven Nordebo	Strategisk kompetensförstärkning	20150053	450,000		450,000
	Total				450,000	0	450,000

CV

Martin Štumpf

Higher Education Qualification

Brno University of Technology, Brno, The Czech Republic

M.Sc., Electrical Engineering, September 2006 – June 2008

- Thesis: "*Implementation and testing of a 2D-integral equation MoM-algorithm for the analysis of power-bus structures on printed circuit boards*"
- Advisor: Marco Leone (**Otto-von-Guericke University, Magdeburg**)

Brno University of Technology, Brno, The Czech Republic

B.Sc., Electrical Engineering, September 2003 – June 2006

- Thesis: "*Analysis of frequency selective surfaces using spectral-domain MoM*" (in Czech)
- Advisor: Ivo Hertl (BUT)

Doctoral Degree

Brno University of Technology, Brno, The Czech Republic

Ph.D., Electrical Engineering, September 2008 – May 2011

- Dissertation: "*Pulsed electromagnetic field radiation from slot antennas*"
- Advisors: Adrianus T. De Hoop, Ioan E. Lager (**TU Delft**), Jaroslav Lacik, Zbynek Raida (BUT)
- *Mathematics Genealogy Project* ID 187111

Postdoctoral Position

Katholieke Universiteit Leuven, Leuven, Belgium

Postdoctoral Research Fellow, August 2011 – December 2012

- Research Topic: "*Time-domain Green's functions associated with layered media*"
- Advisor: Guy A. E. Vandenbosch.

Qualification Required for Appointments as a Docent

Current Position

Assistant Professor, [90% Research/10% Education]
Brno University of Technology - SIX Research Centre
[more information available at www.martin-stumpf.com]

Previous Positions

February - June 2008 — **Otto-von-Guericke University Magdeburg**, Germany
Guest Researcher. Institute for Fundamental Electrical Engineering and Electromagnetic Compatibility. Host: Marco Leone.

February - March 2009 — **Delft University of Technology**, The Netherlands
Guest Researcher. Laboratory for Electromagnetic Research.
Hosts: Ioan E. Lager, Adrianus T. De Hoop.

March 2009 - June 2011 — **Brno University of Technology**, The Czech Republic
Researcher. HIRF-Synthetic Environment, EU FP7 project.
Manager: Z. Raida.

November - December 2009 — **Delft University of Technology**, The Netherlands
Guest Researcher. Laboratory for Electromagnetic Research.
Hosts: Ioan E. Lager, Adrianus T. De Hoop.

October - December 2010 **Delft University of Technology**, The Netherlands
Guest Researcher. Laboratory for Electromagnetic Research.
Hosts: Ioan E. Lager, Adrianus T. De Hoop.

September - October 2014 **Delft University of Technology**, The Netherlands
Guest Researcher. Tera-Hertz Sensing Group/Laboratory for Electromagnetic Research.
Hosts: Ioan E. Lager, Adrianus T. De Hoop.

November - December 2014 **Linnæus University**, Sweden
Guest Researcher. International Center for Mathematical Modeling.
Hosts: Sven Nordebo, Börje Nilsson.

INTERRUPTION IN RESEARCH

SUPERVISION

Brno University of Technology, Brno, The Czech Republic

2014/2015 *Advisor*
Petr Kadlec, Vladimir Sedenka (Postdoctoral Researchers),
"*Tools for synthesis of antennas and sensors*" (project of the Techn. Agency of the Czech Republic)

2010/2011 *Co-supervisor*[1]
Petr Kadlec (PhD Student),
"*Multiobjective optimization of EM structures based on self-organizing migration*" (PhD thesis)

Joint conference contributions:

- P. Kadlec, M. Štumpf and Z. Raida, "Forward scattering from 2D cylinders with dielectric and conductive properties: a step toward the electromagnetic breast imaging," In *Proceedings of the 17th Conference Student EEICT*, Brno, Czech Republic, 28 April 2011, pp. 336–340.
- P. Kadlec, M. Štumpf and Z. Raida, "Adaptive beamforming in time domain," In *Proc. 2011 International Conference on Electromagnetics and Advanced Applications*, Torino, Italy, 12–16 September 2011, pp. 299–302.

OTHER MERITS OF RELEVANCE TO THE APPLICATION

- A Finalist of the 'Best SI/PI Paper Award', *The 2014 IEEE EMC Symposium*, Raleigh, NC, USA, August 2014.
- Young Scientist Award, URSI Commission B *ElectroMagnetic Theory Symposium*, Hiroshima, Japan, May 2013.
- Young Scientist Best Paper Award - 3rd prize, URSI Commission B *ElectroMagnetic Theory Symposium*, Hiroshima, Japan, May 2013.
- Radioengineering Young Scientist Award, *21st International Conference Radioelektronika*, Brno, The Czech Repulic, April 2011.
- Young Scientist Award, URSI Commission B *ElectroMagnetic Theory Symposium*, Berlin, Germany, August 2010.
- Best Diploma Thesis Award in 2008, MTT/AP/ED/EMC Joint Chapter of the Czechoslovak Section of IEEE.
- Award of the Rector of the Brno University of Technology, 2008.
- Award of the Dean of the Faculty of Electrical Engineering and Communication, Brno University of Technology, 2008.
- The Best Paper Award, the conference Student EEICT, 2006.

[1] Non-official co-supervision; according to the Czech system, a senior PhD candidate or a junior PhD graduate is not allowed to supervise a junior PhD candidate.

CV for Sven Nordebo

Personal information
Born on March 2, 1963 in Luleå, Sweden.

1 Basic education

Master of Science in Electrical Engineering, Royal Institute of Technology, Sweden, 1989.

2 Ph.D.

Doctor of Philosophy in signal processing, Luleå University of Technology, Sweden, 1995. Thesis: *Robust Broadband Beamforming and Digital Filter Design*, 1995:173 D, ISSN 0348-8373, Luleå University of Technology, November 1995. Supervisor: Per-Ola Börjesson.

3 Visiting scientist

- Post Doctoral Research Fellow at the Australian Telecommunications Research Institute (ATRI) at Curtin University of Technology in Perth during the period March 1997 to March 1998.
- Visiting Professor George Papanicolaou, Department of Mathematics, Stanford University, March 2003.

4 Docent

Docent in applied signal processing, Blekinge Institute of Technology, 1999.

5 Present position

Professor of signal processing (100%), department of physics and electrical engineering, Linnæus University, Sweden. Employed since 2002. Research 70%.

6 Previous positions

- Senior lecturer in signal processing (100%), department of telecommunications and signal processing, Blekinge Institute of Technology, Sweden, 1995-2002.
- Guest professor of signal processing (20%), department of electrical and information technology, Lund University, Sweden, 2009–2012.

7 Supervision of graduate students

Supervisor and/or assistant supervisor of

1. Mattias Dahl, BTH (ass. supervisor).
   Ph.D degree: M. Dahl, "Applied Array-Filter Design - Methods and Applications", Blekinge Institute of Technology, April 2000.
2. Sven Johansson, BTH (ass. supervisor).
   Ph.D degree: S. Johansson, "Active Control of Propeller–Induced Noise in Aircraft, Algorithms and Methods", Blekinge Institute of Technology, December 2000.
3. Heidi Dam, ATRI (ass. supervisor).
   Ph.D degree: Heidi Dam, "Frequency Domain Filter Design: Structures and Optimization", Curtin University of Technology, Perth, Australia, February 2001.
4. Jörgen Nordberg, BTH (ass. supervisor).
   Ph.D degree: J. Nordberg, "Signal Enhancement in Wireless Communication Systems", Blekinge Institute of Technology, November 2002.
5. Per Persson, BTH (ass. supervisor).
   Ph.D degree: P. Persson, "Annealing Based Optimization Methods for Signal Processing Applications", Blekinge Institute of Technology, May 2003.
6. Jonas Lundbäck, BTH (main supervisor).
   Ph.D degree: J. Lundbäck, "On Signal Processing and Electromagnetic Modelling", Blekinge Institute of Technology, May 2007.
7. Therese Sjödén, Lnu (main supervisor).
   Ph.D degree: Therese Sjödén, "Sensitivity Analysis and Material Parameter Estimation using Electromagnetic Modelling", Linnæus University, June 2012.
8. Stefan Gustafsson, Lnu (main supervisor).
   Ph.D degree: Stefan Gustafsson, "Electromagnetic dispersion modeling and analysis for power cables", Linnæus University, October 2014.

8 Other merits of relevance to the project

Opponent and Examination boards
Sven Nordebo has been opponent for 3 PhD dissertations and 3 licentiate dissertations, and member of the examination committee for 22 PhD dissertations.

Conference organizer
Sven Nordebo has organized *the twentieth Nordic Conference on Radio Science and Communications, RVK08* together with the *third International Conference on Mathematical Modelling of Wave Phenomena, MMWP08* in Växjö in June 9-13, 2008. He has also organized the *Workshop on Mathematical Modelling of Wave Phenomena - with applications in the power industry* in Växjö, April 23-24, 2013.

Associate editor and technical referee for international journals
Sven Nordebo was an associate editor for the *IEEE Transactions on Signal Processing*, 2005-2007. Sven Nordebo is a technical referee for the *IEEE Transactions on Signal Processing*, *IEEE Signal Processing Letters*, *IEEE Transactions on Antennas and Propagation*, *IEEE Transactions on Instrumentation & Measurement*, *IEEE Transactions on Circuits and Systems*, *Radio Science*, *Inverse Problems*.

Administrative experience
Sven Nordebo was dean at the faculty of Mathematics, Natural Sciences and Technology, Växjö University, 2006–2007.

Publication list

Martin Štumpf - Publications

DATABASE **Scopus - Elsevier**

PEER-REVIEWED ORIGINAL ARTICLES

∗ M. Štumpf, I. E. Lager, "The time-domain optical theorem in antenna theory," *IEEE Antennas and Wireless Propagation Letters*, 2015, [accepted, available via IEEE Xplore].

∗ M. Štumpf, "Analysis of dispersive power-ground structures using the time-domain contour integral method," *IEEE Transactions on Electromagnetic Compatibility*, 2015, [accepted, available via IEEE Xplore].

M. Štumpf, Z. Raida, "Pulsed electromagnetic waves between parallel plates: The modal-expansion and generalized-ray approach," *IEEE Antennas and Propagation Magazine*, vol. 56, no. 6, pp. 90–101, December 2014 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "Impulsive electromagnetic response of thin plasmonic metal sheets," *Radio Science*, Special issue '2013 Hiroshima International Symposium on Electromagnetic Theory, vol. 49, no. 8, pp. 689–697, August 2014 [Number of citations: **1**].

∗ M. Štumpf, "Pulsed EM field radiation, mutual coupling, and reciprocity of thin planar antennas," *IEEE Transactions on Antennas and Propagation*, vol. 62, no. 8, pp. 3943–3950, August 2014 [Number of citations: 0].

M. Štumpf, "Radar imaging of impenetrable and penetrable targets from finite-duration pulsed signatures," *IEEE Transactions on Antennas and Propagation*, vol. 62, no. 6, pp. 3035–3042, June 2014 [Number of citations: 0].

M. Štumpf, "Time-domain analysis of rectangular power-ground structures with relaxation," *IEEE Transactions on Electromagnetic Compatibility*, vol. 56, no. 5, pp. 1095–1102 , October 2014 [Number of citations: 0].

∗ M. Štumpf, "The time-domain contour integral method – an approach to the analysis of double-plane circuits," *IEEE Transactions on Electromagnetic Compatibility*, vol. 56, no. 2, pp. 367–374, April 2014 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "On the limitations of the time-domain impedance boundary condition," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 12, pp. 6094–6099, December 2013 [Number of citations: 0].

M. Štumpf, B. Nilsson, "Pulsed acoustic field radiation in a laterally bounded layered fluid," *Journal of Engineering Mathematics*, vol. 87, no. 1, pp. 99–109, August 2013 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "Line-source excited impulsive EM field response of thin plasmonic metal films," *Photonics and Nanostructures - Fundamentals and Applications*, Elsevier, vol. 11, no. 3, pp. 253–260, August 2013 [Number of citations: 0].

M. Štumpf, A. T. De Hoop and G. A. E. Vandenbosch, "Generalized ray theory for time-domain electromagnetic fields in horizontally layered media," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 5, pp. 2676–2687, May 2013 [Number of citations: **2**].

The five most relevant publications to the project are marked with ∗.
The number of citations (excluding self citations) of the five most cited publications is printed in boldface.

M. Štumpf, "An application of the Cagniard-DeHoop technique for solving initial-value problems in bounded regions," *Quarterly Journal of Mechanics and Applied Mathematics*, vol. 66, no. 2, pp. 185–197, February 2013 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "Time-domain behavior of plasmonic half-spaces," *IEEE Photonics Journal*, vol. 4, no. 4, pp. 1236–1246, August 2012 [Number of citations: **1**].

A. T. De Hoop, M. Štumpf and I. E. Lager, "Pulsed electromagnetic field radiation from a wide slot antenna with a dielectric layer," *IEEE Transactions on Antennas and Propagation*, vol. 59, no. 8, pp. 2789–2798, August 2011 [Number of citations: **3**].

M. Štumpf, A. T. De Hoop, and I. E. Lager, "Pulsed electromagnetic field radiation from a narrow slot antenna with a dielectric layer," *Radio Science*, American Geophysical Union, 45, RS5005, doi:10.1029/2009RS004335, October 2010 [Number of citations: 0].

∗ M. Štumpf, M. Leone, "Efficient 2D-integral equation approach for the analysis of power-bus structures with arbitrary shape," *IEEE Transactions on Electromagnetic Compatibility*, vol. 51, no. 1, pp. 38–45, February 2009 [Number of citations: **23**].

PEER-REVIEWED CONFERENCE PAPERS

M. Štumpf, S. Nordebo, "Pulsed EM field propagation in cylindrically layered structures," *The 36th Progress In Electromagnetic Research Symposium*, Prague, The Czech Republic, 06–09 July 2015 [accepted].

M. Štumpf, "Reciprocity-based applications of the time-domain contour integral method," *The 36th Progress In Electromagnetic Research Symposium*, Prague, The Czech Republic, 06–09 July 2015 [accepted].

M. Štumpf, G. A. E. Vandenbosch, "An extension of the time-domain Friis equation," *9th European Conference on Antennas and Propagation EUCAP 2015*, Lisbon, Portugal, 12–17 April 2015 [accepted].

M. Štumpf, "Time-domain mutual coupling between power-ground structures," in *Proc. IEEE International Symposium on Electromagnetic Compatibility*, USA, NC, Raleigh, 3–8 August 2014, pp. 240–243 [not included in the database].

M. Štumpf, "Evaluation of pulsed EM fields in cylindrically layered structures: First steps towards efficient power cable fault detection," in *Proc. of the 7th International Conference 'Inverse Problems: Modeling and Simulation'*, Fethiye, Turkey, 26–31 May 2014, pp. 20–20 [not included in the database].

I. E. Lager, V. Voogt, B. J. Kooij, A. T. De Hoop, M. Štumpf, G. A. E. Vandenbosch, "Time-domain analysis of the pulsed EM field in planarly layered configurations: principles and software implementation," in *Proc. 8th European Conference on Antennas and Propagation EUCAP 2014*, The Hague, The Netlarlands, 6–11 April 2014, pp. 68–72 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "Impulsive electromagnetic response of thin plasmonic metal sheets," in *Proc. International Symposium on Electromagnetic Theory*, URSI Commission B, Hiroshima, Japan, 20–23 May 2013, pp. 258–261 [Number of citations: 0].

G. A. E. Vandenbosch, M. Štumpf, "Electromagnetic energies in time domain the dipole case," in *Proc. International Symposium on Electromagnetic Theory*, URSI Commission B, Hiroshima, Japan, 20–23 May 2013, pp. 180–183 [Number of citations: 0].

M. Štumpf, G. A. E. Vandenbosch, "Time-domain surface impedance of a plasmonic half-space," in *Proc. 6th European Conference on Antennas and Propagation EUCAP 2012*, Prague, The Czech

Republic, 26–30 March 2012, pp. 1–4 [Number of citations: 0].

A. T. De Hoop, H. Blok, I. E. Lager, M. Štumpf, G. A. E. Vandenbosch, "Pulsed-field EMI susceptibility analysis of microelectronic circuits - a full time-domain methodology", in *Proc. of European Microwave Week 2012*, Amsterdam, The Netherlands, 28 October – 2 November 2012, pp. 337–339 [Number of citations: 1].

M. Štumpf, "An alternative look at the formulation of 2D contour integral method," in *Proc. International Conference Radioelektronika 2011*, Dept. of Radio Electronics, Brno, 19–20 April 2011, pp. 327–329 [Number of citations: 0].

M. Štumpf, A. T. De Hoop, I. E. Lager, "Closed-form time-domain expressions for the 2D pulsed EM field radiated by an array of slot antennas of finite width," in *Proc. International Symposium on Electromagnetic Theory*, URSI Commission B, Berlin, Germany, 16–19 August 2010, pp. 786–789 [Number of citations: 1].

M. Štumpf, O. Kröning, M. Leone, "Power-bus modeling using 2D-integral-equation formulation," in *Proc. 20th International Symposium on Electromagnetic Compatibility EMC Zurich 2009*, Zurich, Switzerland, 12–16 January 2009, pp. 189–192 [Number of citations: 0].

MONOGRAPHS

RESEARCH REVIEW ARTICLES

BOOKS AND BOOK CHAPTERS

M. Štumpf, A. T. De Hoop and G. A. E. Vandenbosch, "Generalized-ray theory for electromagnetic fields," In I. E. Lager and L. Jiang (editors), *Pulsed Electromagnetic Fields: Their Potentialities, Computation and Evaluation*, Proc. of the Workshop, Held in Honor of Prof. Dr. A. T. De Hoop and Prof. W. C. Chew, Delft, The Netherlands, Delft University Press/IOS Press, ISBN: 978-1-61499-229-5, pp. 75–88, 2013 [not included in the database].

M. Štumpf, *Integral Formulations of Electromagnetic-Field Problems and Their Applications*," Brno, The Czech Republic, Litera Brno, ISBN: 978-80-214-4869-8, 2014, 84 pp. (in Czech) [not included in the database].

PATENTS

OPEN ACCESS COMPUTER PROGRAMS OR DATABASES

M. Štumpf, "Analysis of frequency selective surfaces," In Z. Raida (editor), *Multimedia Textbook of Electromagnetic Waves and Microwave Technique*, Brno, The Czech Republic, Brno University of Technology, available at `http://www.urel.feec.vutbr.cz/~raida/multimedia/index.php?lang=en`.

M. Štumpf, Pulsed ElectroMagnetic Field radiated from arrays of slots (PEMF), *HIRF Synthetic Environment*, EU FP7 Project no. 205294.

POPULAR SCIENCE ARTICLES AND PRESENTATIONS

List of publications for Sven Nordebo

Citation data

The citation data has been obtained by use of the *Google Scholar*. The five most cited scientific papers are:

1. M. Gustafsson, S. Nordebo, "Bandwidth, Q factor, and Resonance Models of Antennas", *Progress in Electromagnetics Research PIER*, vol. 62, pp. 1-20, 2006.
   Number of citations: 83.

2. S. Nordebo, I. Claesson, S. Nordholm, "Weighted Chebyshev Approximation for the Design of Broadband Beamformers Using Quadratic Programming", in *IEEE Signal Processing Letters*, vol. 1, no. 7, pp. 103–105, July 1994.
   Number of citations: 55.

3. S. Nordebo, Z. Zang, I. Claesson, "A Semi–Infinite Quadratic Programming Algorithm with Applications to Array Pattern Synthesis", in *IEEE Transactions on Circuits and Systems–II: Analog and Digital Signal Processing*, vol. 48, no. 3, pp. 225–232, March 2001.
   Number of citations: 53.

4. S. Nordebo, Z. Zang, "Semi–Infinite Linear Programming: A Unified Approach to Digital Filter Design with Time and Frequency Domain Specifications", in *IEEE Transactions on Circuits and Systems–II: Analog and Digital Signal Processing*, vol. 46, no. 6, pp. 765–775, June 1999.
   Number of citations: 44.

5. S. Nordebo, I. Claesson, S. Nordholm, "Adaptive Beamforming: Spatial Filter Designed Blocking Matrix", in *IEEE Journal of Oceanic Engineering*, vol. 19, no. 4, pp. 583–590, October 1994.
   Number of citations: 44.

1. Peer-reviewed original articles 2008–2015

1. J. Lundbäck, S. Nordebo and T. Biro, "A Digital Directional Coupler with Applications to Partial Discharge Measurements", *IEEE Transactions on Instrumentation and Measurements*, vol. 57, no. 11, pp. 2561–2567, 2008. *Number of citations: 4.*

2. S. Nordebo, A. Fhager, M. Gustafsson, M. Persson, "A Systematic Approach to Robust Preconditioning for Gradient Based Inverse Scattering Algorithms", *Inverse Problems*, vol. 24, no. 2, pp. 025027, 2008. *Number of citations: 23.*

3. B. Nilsson, S. Nordebo, T. Sjödén, "Estimation of twist in uniaxial cylinders with inverse electromagnetic scattering", *IEEE Transactions on Antennas and Propagation*, vol. 57, no. 10, pp. 3264–3273, 2009. *Number of citations: 1.*

4. S. Nordebo, M. Gustafsson, "A priori modeling for gradient based inverse scattering algorithms", *Progress In Electromagnetics Research B*, vol. 16, 407–432, 2009. *Number of citations: 3.*

5. M. Gustafsson, M. Cismasu, S. Nordebo, "Absorption Efficiency and Physical Bounds on Antennas", *International Journal of Antennas and Propagation*, vol. 2010, article ID 946746, pp. 1–7, 2010. *Number of citations: 20.*

6. S. Nordebo, A. Fhager, M. Gustafsson, B. Nilsson, "A Green's function approach to Fisher information analysis and preconditioning in microwave tomography", *Inverse Problems in Science and Engineering*, vol. 18, no. 8, pp. 1043–1063, December 2010. *Number of citations: 11.*

7. S. Nordebo, R. Bayford, B. Bengtsson, A. Fhager, M. Gustafsson, P. Hashemzadeh, B. Nilsson, T. Rylander and T. Sjöden, "An adjoint field approach to Fisher information based sensitivity analysis in electrical impedance tomography", *Inverse Problems*, vol. 26, 125008, 2010. *Number of citations: 8.*

8. M. Proto, M. Bavusi, R. Bernini, L. Bigagli, M. Bost, F. Bourquin, L. M. Cottineau, V. Cuomo, P. D. Vecchia, M. Dolce, J. Dumoulin, L. Eppelbaum, G. Fornaro, M. Gustafsson, J. Hugenschimdt, P. Kaspersen, H. Kim, V. Lapenna, M. Leggio, A. Loperte, P. Mazzetti, C. Moroni, S. Nativi, S. Nordebo, F. Pacini, A. Palombo, S. Pascucci, A. Perrone, S. Pignatti, F. C. Ponzo, E. Rizzo, F. Soldovieri, F. Taillade, "Transport infrastructure surveillance and monitoring by electromagnetic sensing: the ISTIMES project", *Sensors*, vol. 10, no. 12, pp. 10620-10639, 2010. *Number of citations: 34.*

9. S. Nordebo, A. Bernland, M. Gustafsson, C. Sohl, G. Kristensson, "On the relation between optimal wideband matching and scattering of spherical waves", *IEEE Transactions on Antennas and Propagation*, vol. 59, no. 9, pp. 3358–3369, 2011. *Number of citations: 3.*

10. A. Bernland, M. Gustafsson, S. Nordebo, "Physical limitations on the scattering of electromagnetic vector spherical waves", *J. Phys. A: Math. Theor.*, vol. 44, no. 14, pp. 145401-, 2011. *Number of citations: 5.*

11. S. Nordebo, M. Gustafsson, F. Soldovieri, "Data fusion for reconstruction algorithms via different sensors in geophysical sensing", *Journal of Geophysics and Engineering*, vol. 8, pp. S54-S60, 2011. *Number of citations: 2.*

12. S. Nordebo, M. Gustafsson, T. Sjöden, F. Soldovieri, "Data fusion for electromagnetic and electrical resistive tomography based on maximum likelihood", *International Journal of Geophysics*, Article ID 617089, pp. 1-11, 2011. *Number of citations: 4.*

13. A. Fhager, M. Gustafsson, S. Nordebo, "Image reconstruction in microwave tomography using a dielectric Debye model", *IEEE Transactions on Biomedical Engineering*, vol. 59, no. 1, pp. 156–166, 2012. *Number of citations: 15.*

14. A. Khrennikov, B. Nilsson, S. Nordebo, I. V. Volovich, "Quantization of propagating modes in optical fibres", *Phys. Scr.*, vol. 85, 2012. 065404. *Number of citations: 8.*

15. J. Toft, A. Khrennikov, B. Nilsson, S. Nordebo, "Decomposition of Gelfand-Shilov kernels into kernels of similar class", *Journal of Mathematical Analysis and Applications*, vol. 396, no. 1, pp. 315–322, 2012. *Number of citations: 11.*

16. S. Nordebo, M. Gustafsson, A. Khrennikov, B. Nilsson, J. Toft, "Fisher information for inverse problems and trace class operators", *Journal of Mathematical Physics*, vol. 53, 123503-, 2012. *Number of citations: 2.*

17. M. Gustafsson, S. Nordebo, "Optimal antenna currents for Q, superdirectivity, and radiation patterns using convex optimization", *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 3, pp. 1109–1118, 2013. *Number of citations: 34.*

18. *S. Nordebo, B. Nilsson, T. Biro, G. Cinar, M. Gustafsson, S. Gustafsson, A. Karlsson, M. Sjöberg, "Low-frequency dispersion characteristics of a multilayered coaxial cable", *Journal of Engineering Mathematics*, DOI 10.1007/s10665-012-9616-3, vol. 83, no. 1, pp. 169–184, 2013. *Number of citations: 8.*

19. S. Nordebo, M. Gustafsson, B. Nilsson, T. Sjöden, F. Soldovieri, "Fisher information analysis in electrical impedance tomography", *Journal of Geophysics and Engineering*, vol. 10, no. 6, 2013. *Number of citations: 2.*

20. *S. Aksimsek, G. Cinar, B. Nilsson, S. Nordebo, "TEM wave scattering by a step discontinuity on the outer wall of a coaxial waveguide", *IEEE Transactions on microwave theory and techniques*, vol. 61, no. 8, pp. 2783–2791, 2013. *Number of citations: 2.*

21. *S. Nordebo, G. Cinar, S. Gustafsson, A. Ioannidis, B. Nilsson, "Asymptotic analysis of non-discrete radiating modes for open waveguide structures", *Mathematical Methods in the Applied Sciences*, DOI: 10.1002/mma.2821, vol. 37, pp. 251–256, 2014. *Number of citations: 2.*

22. *S. Nordebo, B. Nilsson, T. Biro, G. Cinar, M. Gustafsson, S. Gustafsson, A. Karlsson, M. Sjöberg, "Electromagnetic dispersion modeling and measurements for HVDC power cables", *IEEE Transactions on Power Delivery*, vol. 29, no. 6, pp. 2439–2447, 2014.

23. S. Nordebo, M. Gustafsson, B. Nilsson, D. Sjöberg, "Optimal realizations of passive structures", *IEEE Transactions on Antennas and Propagation*, vol. 62, no. 9, pp. 4686–4694, 2014. *Number of citations: 0.*

24. I. Vakili, M. Gustafsson, D. Sjöberg, R. Seviour, M. Nilsson, S. Nordebo, "Sum Rules for Parallel Plate Waveguides: Experimental Results and Theory", *IEEE Transactions on Microwave Theory and Techniques*, vol. 62, no. 11, pp. 2574–2582, 2014. *Number of citations: 1.*

25. S. Nordebo, A. Gustafsson, "A Quasi-Static Electromagnetic Analysis for Experiments with Strong Permanent Magnets", *Progress In Electromagnetics Research B*, vol. 61, pp. 1-16, 2014. *Number of citations: 0.*

26. *S. Nordebo, G. Cinar, S. Gustafsson, B. Nilsson, "Dispersion modeling and analysis for multilayered open coaxial waveguides", accepted for publication in *IEEE Transactions on Microwave Theory and Techniques*, 2015.

2. Peer-reviewed conference contributions 2008–2015

1. M. Gustafsson, C. Sohl, S. Nordebo, "Physical bounds on the antenna scattering matrix", *Proceedings of 2008 IEEE Antennas and Propagation Society International Symposium*, pp. 1–4, 2008. *Number of citations: 5.*

2. C. Sohl, M. Gustafsson, G. Kristensson, S. Nordebo, "A general approach for deriving bounds in electromagnetic theory", *Proceedings of URSI 19 General Assembly*, B01.4, August 2008. *Number of citations: 6.*

3. S. Nordebo, M. Gustafsson, C. Sohl, G. Kristensson, "On the optimal limitations for scattering of spherical modes", *Proceedings of URSI 19 General Assembly*, BP15.4, August 2008. *Number of citations: 1.*

4. S. Nordebo, B. Nilsson, O. Lindhe, "Estimation of Parameters of an Inhomogeneous Dielectric Layer", *3rd Conference on Mathematical Modelling of Wave Phenomena*, Växjö, Sweden, 9 – 13 June 2008. AIP Conference Proceeding 1106, pp. 94–103, 2009. *Number of citations: 2.*

5. T. Sjödén, B. Nilsson, S. Nordebo, "Numerical Verification of a Microwave Impedance Model for a Twisted Wooden Cylinder", *3rd Conference on Mathematical Modelling of Wave Phenomena*, Växjö, Sweden, 9 – 13 June 2008. AIP Conference Proceeding 1106, pp. 243–252, 2009. *Number of citations: 2.*

6. M. Gustafsson, C. Sohl, G. Kristensson, S. Nordebo, C. Larsson, A. Bernland, D. Sjöberg, "An overview of some recent physical bounds in scattering and antenna theory", *3rd European Conference on Antennas and Propagation*, Berlin, Germany, pp. 1795–1798, 2009. *Number of citations: 5.*

7. S. Nordebo, A. Fhager, M. Gustafsson, B. Nilsson, "Applications of the Fisher information integral operator for inverse problems", *The 9th International Conference on Mathematical and Numerical Aspects of Waves Propagation*, Pau, France, pp. 302–303, 2009. *Number of citations: 1.*

8. A. Bernland, M. Gustafsson, S. Nordebo, "Summation rules and physical bounds for partial wave scattering in electromagnetics", *The 9:th International Conference on Mathematical and Numerical Aspects of Waves Propagation*, Pau, France, pp. 206–207, 2009. *Number of citations: 1.*

9. M. Gustafsson, G. Kristensson, S. Nordebo, C. Larsson, A. Bernland, D. Sjöberg, "Physical bounds and sum rules in scattering and antenna theory", *International Conference on Electromagnetics in Advanced Applications (ICEAA)*, Torino, 2009. *Number of citations: 1.*

10. S. Nordebo, A. Fhager, M. Gustafsson, B. Nilsson, "Fisher information analysis in microwave tomography", *The Third International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP09)*, pp. 217–220, Aruba, Dec. 13–16, 2009. ISBN: 978-1-4244-5180-7. *Number of citations: 1.*

11. S. Nordebo, R. Bayford, B. Bengtsson, A. Fhager, M. Gustafsson, P. Hashemzadeh, B. Nilsson, T. Rylander, T. Sjöden, "Fisher information analysis and preconditioning in electrical impedance tomography", *Journal of Physics: Conference Series*, vol. 224, 012057, 2010. *Number of citations: 2.*

12. S. Nordebo and M. Gustafsson and F. Soldovieri, "Data fusion for reconstruction algorithms via different sensors in geophysical sensing", *European Geosciences Union General Assembly*, Vienna, Austria, 2–7 May, 2010. *Number of citations: 2.*

13. S. Nordebo, B. Bengtsson, M. Gustafsson, B. Nilsson, T. Sjödén, "Fisher information analysis and gradient based optimization for electrical impedance tomography", *5th International Conference on Inverse Problems, Modeling and Simulation*, Antalya, Turkey, 24–29 May, 2010. *Number of citations: 0.*

14. T. Sjödén, B. Nilsson, S. Nordebo, "Determination of wood parameters using electromagnetic measurements", *5th International Conference on Inverse Problems, Modeling and Simulation*, pp. 70–71, Antalya, Turkey, 24–29 May, 2010. *Number of citations: 0.*

15. S. Nordebo, M. Gustafsson, F. Soldovieri, "Tunnel detection based on data fusion with radio frequency and electrical resistive tomography", *European Geosciences Union General Assembly*, Vienna, Austria, 3–8 April, 2011. *Number of citations: 1.*

16. B. Nilsson, S. Nordebo, A. Karlsson, G. Cinar, "Simulation of electromagnetic pulses in waveguides at large distances", International Conference on Electromagnetics in Advanced Applications (ICEAA11), pp. 640–643, 2011. *Number of citations: 3.*

17. S. Nordebo, B. Nilsson, T. Biro, G. Cinar, M. Gustafsson, S. Gustafsson, A. Karlsson, M. Sjöberg, "Wave modeling and fault localization for underwater power cables", International Conference on Electromagnetics in Advanced Applications (ICEAA11), pp. 698–701, 2011. *Number of citations: 9.*

18. P. Hashemzadeh, P. Kantaritzis, P. Liatsis, R. Bayford, S. Nordebo, "A Cramér-Rao Bound Approach for Evaluating the Quality of Experimental Setups in Electrical Impedance Tomography", *Proceeding (723) Biomedical Engineering*, 2011. *Number of citations: 1.*

19. T. Sjödén, M. Gustafsson, S. Nordebo, F. Soldovieri, "Fisher information analysis in electrical impedance tomography", *European Geosciences Union General Assembly*, Vienna, Austria, 22–27 April, 2012. *Number of citations: 2.*

20. S. Nordebo, M. Gustafsson, J. Dumoulin, A. Perrone, S. Pignatti, F. Soldovieri, "Frequency analysis and data correlation for beam displacement measurements based on the ISTIMES campaign in Montagnole", *European Geosciences Union General Assembly*, Vienna, Austria, 22–27 April, 2012. *Number of citations: 1.*

21. S. Nordebo, S. Gustafsson, B. Nilsson, "Fault localization for HVDC Power Cables", *The 6th International Conference on Inverse Problems: Modeling and Simulation*, p. 208, Antalya, Turkey, May 21-26, 2012. *Number of citations: 1.*

22. B. Nilsson, G. Cinar, S. Nordebo, Ö. Yanaz Cinar, "Asymptotic Methods for Long Distance Monitoring of Power Cables", *The 6th International Conference on Inverse Problems: Modeling and Simulation*, pp. 206–207, Antalya, Turkey, May 21-26, 2012. *Number of citations: 6.*

23. S. Gustafsson, S. Nordebo, B. Nilsson, "An electromagnetic dispersion model for HVDC Power Cables", *The 6th International Conference on Inverse Problems: Modeling and Simulation*, pp. 214–215, Antalya, Turkey, May 21-26, 2012. *Number of citations: 1.*

24. T. Sjödén, S. Nordebo, B. Nilsson, "Sensitivity analysis for inverse problems in Electrical Impedance Tomography", *The 6th International Conference on Inverse Problems: Modeling and Simulation*, pp. 220–221, Antalya, Turkey, May 21-26, 2012. *Number of citations: 1.*

25. M. Gustafsson, M. Cismasu, S. Nordebo, "Physical bounds on small antennas as convex optimization problems", *IEEE International Symposium on Antennas and Propagation*, Chicago, US, 2012-07-09. *Number of citations: 3.*

26. S. Nordebo, S. Gustafsson, A. Ioannidis, B. Nilsson, J. Toft, "On the generalized Jordans lemma with applications in waveguide theory", Proceedings of the *2013 International Symposium on Electromagnetic Theory, EMTS 2013*, 1039–1042, 2013. *Number of citations: 1.*

27. A. Ioannidis, B. Nilsson, S. Nordebo, "A mathematical framework for propagation in an open cavity", Proceedings of the *2013 International Symposium on Electromagnetic Theory, EMTS 2013*, 1043–1046, 2013. *Number of citations: 1.*

28. S. Nordebo, A. Ioannidis, B. Nilsson, "Reduced volume integral formulations for an open waveguide based on the cylindrical vector wave expansion", Proceedings of the *Progress In Electromagnetics Research Symposium, PIERS-2013*, 633–637, 2013.

29. D. Sjöberg, S. Nordebo, M. Gustafsson, "Convex optimization for optimal realization of material properties", *International Conference on Electromagnetics in Advanced Applications (ICEAA)*, Aruba, pp. 782-785, 2014-08-03/2014-08-08.

3. Patents

1. S. Nordebo and J. Lundbäck and T. Biro, Method and device for monitoring a system, Swedish patent: 0602043-2 (approved 2008), PCT/SE2007/000841.

4. Other publications 2008–2015

1. S. Nordebo, B. Nilsson, O. Lindhe, "Estimation of Parameters of an Inhomogeneous Dielectric Layer", *Radiovetenskaplig konferens RVK*, Växjö, Sweden, June 2008.

2. T. Sjödén, B. Nilsson, S. Nordebo, "Sensitivity Analysis for the Estimation of Twist in Logs based on Microwave Scattering", *Radiovetenskaplig konferens RVK*, Växjö, Sweden, June 2008.

3. S. Nordebo, S. Gustafsson, B. Nilsson, "Wave modeling for HVDC power cables", *Radiovetenskaplig konferens RVK*, Stockholm, Sweden, March 2012.

4. S. Nordebo, S. Gustafsson, A. Ioannidis, B. Nilsson, "System identification for wave guides with complicated structure and complex media", *Modern Mathematical Methods in Science and Technology (M3ST)*, Kalamata, Greece, August 26–28, 2012.

5. S. Nordebo, M. Gustafsson, "Computational challenges in convex optimization for antenna analysis", Proceedings of the *Progress In Electromagnetics Research Symposium, PIERS-2014*, 2014.

6. S. Nordebo, M. Gustafsson, B. Nilsson, "Inverse source problem for cable measurements with finitely supported excitation", Proceedings of the *Progress In Electromagnetics Research Symposium, PIERS-2014*, 2014.

CV

Name: Martin Stumpf	**Doctorial degree:** 2011-05-05
Birthdate: 19830922	**Academic title:** Annan
Gender: Male	**Employer:** Brno University of Technology

Research education

Dissertation title (swe)
Pulsad Elektromagnetisk Strålning från Slot-antenner

Dissertation title (en)
Pulsed Electromagnetic Field Radiation from Slot Antennas

Organisation	Unit	Supervisor
Brno University of Technology, Czech Not Sweden - Higher Education institutes		Adrianus De Hoop

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20203. Kommunikationssystem		2011-05-05

CV

Name: Sven Nordebo	**Doctorial degree:** 1995-11-21
Birthdate: 19630302	**Academic title:** Professor
Gender: Male	**Employer:** Linnéuniversitetet

Research education

Dissertation title (swe)

Robust bredbandig lobformning och digital filterdesign

Dissertation title (en)

Robust Broadband Beamforming and Digital Filter Design

Organisation	Unit	Supervisor
Luleå Tekniska Universitet, Sweden Sweden - Higher education Institutes	Institutionen för system- och rymdteknik	Per-Ola Börjesson

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20205. Signalbehandling	ISSN 0348-8373	1995-11-21

Publications

Name: Martin Stumpf	**Doctorial degree:** 2011-05-05
Birthdate: 19830922	**Academic title:** Annan
Gender: Male	**Employer:** Brno University of Technology

Stumpf, Martin has not added any publications to the application.

Publications

Name: Sven Nordebo	**Doctorial degree:** 1995-11-21
Birthdate: 19630302	**Academic title:** Professor
Gender: Male	**Employer:** Linnéuniversitetet

Nordebo, Sven has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.