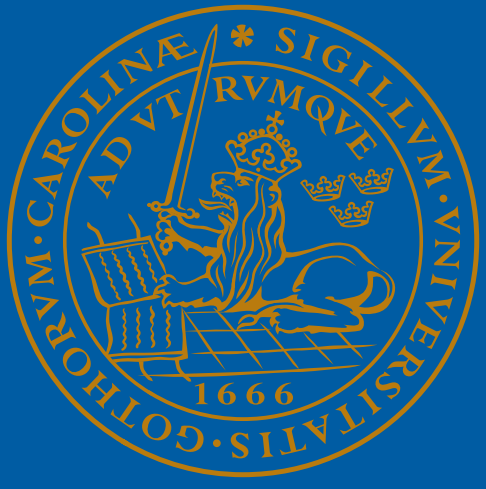
CODEN:LUTEDX/(TEAT-3023)/1-51/(2012)

Annual Report 2011

Electromagnetic Theory

Electromagnetic Theory
Department of Electrical and Information Technology
Lund University
Sweden



Editors: Gerhard Kristensson & Christian Sohl

Lund, July 23, 2012

Preface

Mats Gustafsson and Daniel Sjöberg were appointed professors in Electromagnetic theory at Lund University during 2011, see the figure on page ii. This is, of course, an historical event in the scientific endeavor of the group. On behalf of the entire group, we congratulate both of them to this accomplishment.

Dissertations are also a receipt on successful scientific activities. In June Vanja Plicanic successfully defended her PhD thesis with Professor Ernst Bonek, Vienna Technical University, as faculty opponent. More about the event is found in Section 3.1 on page 11.

Figure 1: Vanja Plicanic officially nails her thesis to the board outside the E-building library.

Also in June, Peter Johannesson presented his Licentiate dissertation. A short summary of his thesis is found in Section 3.2.1 on page 13.

The scientific activities of the group are steadily increasing, which is encouraging. The two large facilities in Lund, MAX IV and ESS, that are under construction, generate many interesting scientific questions and research. In the Electromagnetic Theory group, Anders Karlsson is now involved in several scientific project with focus on microwave cavities.

During 2011, two new PhD students, Iman Vakili and Renato de Prisco, started their graduate studies in the group, see Figure 3. We wish both these new colleagues good luck in their studies and endeavors.

Our research depends very much on financial support from external sources. In Section 1.7 on page 4 a complete list of external funding during 2011 is presented. We are fortunate to have support from a number of sources including the Swedish Research Council (VR), the FP7 Programme (EU), VINNOVA, the Swedish Foundation for Strategic Research (SSF), Sony Ericsson Mobile Communications AB, and the Swedish Defence Materiel Administration (FMV). We are very grateful to these organizations for their generous supports.

A great deal of work is done in collaboration with researchers from leading Swedish industry. This is borne out by the many Adjunct professors that we have in the group, see Section 1.4 on page 4. We see strong mutual benefits from both parts in this interaction, and we are looking forward to continuing and deepening this collaboration.

Under the auspices of the Swedish Defence Materiel Administration (FMV), we have completed a very interesting project on micromodeling of absorbing structures. This

project was multidisciplinary and enroled researchers from FOI and the industry. We value these projects highly, since they give us insight into the problems that the leading Swedish industry are facing.

Figure 2: The new professors at Lund University. Daniel Sjöberg and Mats Gustafsson are standing on the right side of the Vice-Chancellor Per Eriksson in the center.

Figure 3: New members of the group. From left: Iman Vakili and Renato de Prisco.

Many conferences have been attended by the members of the group during 2011. The most important was the XXX$^{\text{th}}$ URSI General Assembly in Istanbul, Turkey, August 13–20, 2011. This conference and the work in the international organization URSI engage many of the scientists in the group. A list of our efforts at conferences during 2011 is presented on page 30.

Contents

1 The group of Electromagnetic Theory

1.1 General

The Faculty of Engineering (Lunds Tekniska Högskola, LTH) is Sweden's third largest higher educational institute for the engineering sciences, and it is part of Lund University — one of the oldest and largest universities in Scandinavia. The Faculty of Engineering consists of 19 departments, some of which are divided into divisions.

The basis for the research and teaching activities in the group of Electromagnetic Theory at the Department of Electrical and Information Technology is the fundamental macroscopic electromagnetic laws as they apply to the generation and propagation of electromagnetic waves in vacuum or in material media. Special emphasis is also given to the theoretical study of the various devices that can be constructed to amplify and regulate these effects. In our ambition to meet these goals all methods — analytical, numerical, and experimental — are relevant to us.

The main research activities are concentrated to the area of electromagnetic scattering theory and related topics, *e.g.*, antenna and radome applications. Progress in this area is fundamental for the development of devices and tools that use electromagnetic waves for information exchange. The last few decades have very clearly showed an increasing need and demand for this kind of sensors and carriers of information.

During the last decade, wave propagation phenomena in periodic structures have been a prosperous research field in the group of Electromagnetic Theory. For larger structures, where the wavelength is comparable to the periodicity of the material, the frequency selective structures (FSS) are a striking example of this effort. On the other end of the scale, with a vanishingly small periodicity, we address the field of homogenization. This application makes it possible to find the effective electromagnetic parameters of a material exactly in terms of the microscopic constituents (microstructure) of the material.

Multiple antenna systems have received much interest due to the ability to increase the spectral efficiency in wireless communication. In many cases it is desired to have both high capacity and small physical size. Research has been directed towards establishing physical limitations on information capacity based on antenna size, keyhole effects, and the wave propagation environment. A related area is the study of antenna signal correlation among closely spaced elements.

The two largest research facilities in Sweden, MAX IV and the European Spallation Source (ESS), are being built in Lund. This is making Lund one of Europe's major centers of accelerator technique. Since 2010 we have gradually increased our activities in this field and started joint projects with both Maxlab and ESS. In December 2011 we are involved in the design of the drift tube linac (DTL) for ESS and we have signed contracts for other projects that will start during 2012.

1.2 Personnel

The personnel employed in the group during 2011 is given in the following table:

Name	Degree[a]	Position[b]
Anders Bernland	TeknL	D
Alexander Bondarik	MSc	D
Marius Cismasu	MSc	D
Mats Gustafsson	TeknD, Doc	P
Anders Karlsson	TeknD, Doc	P
Alireza Kazemzadeh	TeknD	FA
Buon Kiong (Vincent) Lau[c]	TeknD, Doc	UL
Gerhard Kristensson	FD, Doc	P
Richard Lundin	TeknD	UL
Sven Nordebo[d]	TeknD	P
Kristin Persson	TeknL	D
Christian Sohl	TeknD	FA
Daniel Sjöberg	TeknD, Doc	P
Ruiyuan Tian[e]	MSc	D
Iman Vakili[f]	MSc	D

[a] Doc Docent; FD Doctor of Philosophy, PhD; MSc Master of Science; TeknD PhD in Engineering; TeknL Licentiate in Engineering

[b] D Graduate Student; FA Postdoctoral Research Fellow; P Professor; UL Senior Lecturer

[c] Employed by the Communications group.

[d] From Linnæus University. Part time employed during 2011.

[e] Employed by the Communications group.

[f] Started his employment 2011-06-20.

A photo of the group is given in Figure 4.

1.3 External graduate students (industridoktorander)

Under this heading we list those graduate students of the group that are fully employed at a company and at the same time are graduate students in the group of Electromagnetic Theory.

Figure 4: The Electromagnetic Theory group. From the left: Gabriele Costanza, Christer Larsson, Alexander Bondarik, Mats Gustafsson, Anders Bernland, Gerhard Kristensson, Buon Kiong (Vincent) Lau, Iman Vakili, Kristin Persson, Alireza Kazemzadeh, Anders Sunesson, Richard Lundin, Daniel Sjöberg, Marius Cismasu, and Christian Sohl. The photo was taken February 17, 2012. Missing on the photo are Michael Andersson, Anders Derneryd, Magnus Gustafsson, Anders Karlsson, Sven Nordebo, Vanja Plicanic, Renato de Prisco, and Niklas Wellander.

Name	**Degree**[a]	**Company**
Michael Andersson	TeknL	Applied Composites AB, Linköping
Magnus Gustafsson	CI	Swedish Defence Research Agency, FOI
Vanja Plicanic[b]	TeknL	Sony Ericsson Mobile Communications, Lund
Renato de Prisco[c]	MSc	European Spallation Source (ESS)

[a] CI Master of Engineering
TeknL Licentiate in Engineering
[b]Finished her studies 2011-06-14.
[c]Started his employment 2011-11-01.

1.4 Adjunct professors

Four adjunct professors are associated with the group of Electromagnetic Theory:

Name	Degree[a]	Company
Anders Derneryd	TeknD	Ericsson AB
Christer Larsson	FD, Doc	Saab Dynamics AB
Anders Sunesson	TeknD	Liteonmobile
Niklas Wellander	TeknD	Swedish Defence Research Agency, FOI

[a] Doc Docent
FD Doctor of Philosophy, PhD
TeknD PhD in Engineering

1.5 Visiting scientists

Several Visiting scientists take part in the scientific activities and participate in joint projects with researchers in the group. These are:

Name	University
Sena Esen Bayer Keskin[a]	Kocaeli University, Turkey
Jørgen Bach Andersson	Aalborg University, Denmark
Andreas Ioannidis	Aristotelean University of Thessaloniki, Greece

[a] Returned to Turkey on September 3, 2011.

1.6 URL-address

The home page of the Department of Electrical and Information Technology is: **www.eit.lth.se/research/emtheory**. From this home page it is easy to find more, and up to date, information of the group of Electromagnetic Theory.

1.7 External funding

The external research support during 2011 is given by:

- The Swedish Research Council (VR). *Principal investigator:* Mats Gustafsson. *Title of the project:* "Physical bounds on the information capacity for MIMO and UWB antenna systems".
- The Swedish Research Council (VR). *Principal investigator:* Buon Kiong Lau. *Title of the project:* "Fundamentala begränsningar för små bredbandiga MIMO-System (Fundamental Limits of Wideband Information Capacity for Compact MIMO Systems)".

- The Swedish Research Council (VR). *Principal investigator:* Buon Kiong Lau. *Title of the project:* "Ny antenn system design paradigm for hög prestanda i mobil kommunikation (Novel Antenna System Design Paradigm for High Performance Mobile Communications)".

- VINNOVA. *Principal investigator:* Buon Kiong Lau. *Title of the project:* "Harmonisering av Antenn och Kanal för Ökad Överföringshastighet i Avancerade Mobila Terminaler (Antenna-Channel Harmonization for Throughput Enhancement in Advanced Mobile Terminals)".

- VINNOVA. *Principal investigator:* Buon Kiong Lau. *Title of the project:* "Innovativ Multipelantenn Design för Kompakta Terminaler (Innovative Multiple Antenna Structures for Compact Mobile Terminals)".

- VINNOVA. *Principal investigators:* Mats Gustafsson and Buon Kiong Lau. *Title of the project:* "Access technologies: multiple access, multiple users, multiple distributed antenna systems".

- VINNOVA. National Aeronautical Research Program (NFFP5). *Principal investigators:* Daniel Sjöberg. *Title of the project:* "Signature reduction of hull-integrated broadband antennas".

- SSF Strategic Mobility Grant. *Principal investigator:* Anders Karlsson.

- SSF Strategic Mobility Grant. *Principal investigator:* Daniel Sjöberg.

- FP7 Programme, EU. *Principal investigator:* Mats Gustafsson. *Title of the project:* "Integrated System for Transport Infrastructures surveillance and Monitoring by Electromagnetic Sensing".

- Swedish Defence Materiel Administration (FMV), sponsoring several projects in collaboration with Swedish industry.

- Ericsson AB. Sponsoring the Adjunct professorship of Anders Derneryd.

- Saab Dynamics AB. Sponsoring the Adjunct professorship of Christer Larsson.

- Swedish Defence Research Agency, FOI. Sponsoring the Adjunct professorship of Niklas Wellander.

- European Spallation Source (ESS). Financing of an external graduate student. *Title of the project:* "Design of drift tube linac for ESS".

- Sony Ericsson Mobile Communications AB. Financing of an external graduate student.

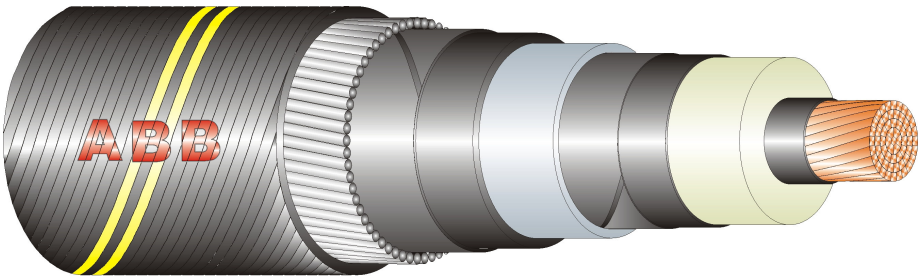


Figure 5: Example of a project under Section 2.1. Cross-section of the extruded HVDC sea cable.

2 Research Activities

The current research projects of the group of Electromagnetic Theory are organized in four major categories:

2.1 Material modeling and electromagnetic interaction

2.2 Electromagnetic scattering and design

2.3 Inverse scattering and imaging

2.4 Antennas and communication

2.5 Accelerator technique

For each category, we give a short general description followed by a list of recent literature produced within the group. Only journal papers are cited explicitly, which serves the double purpose of documenting the researchers involved, and providing key words describing the activities. Full references for conference contributions and technical reports can be found in Sections 3.5 and 3.8, respectively.

2.1 Material modeling and electromagnetic interaction

In these projects, the focus is on the interaction between the electromagnetic field and material structures. This includes wave propagation in complex materials and structures (inhomogeneous, nonlinear, anisotropic, chiral, frequency selective etc), as well as mathematical modeling of physical mechanisms behind the interaction (representations of dispersive effects, homogenization).

Primary questions in these projects regard the possibilities to reduce the amount of information needed to describe the interaction. For instance, wave propagation in

strongly inhomogeneous media (many parameters) can be modeled with propagation in homogeneous materials (very few parameters) if the wavelength is sufficiently long. This reduction is called homogenization. The properties of the fictitious homogeneous material must be carefully calculated, usually from a static or quasi-static field problem. In another class of problems, interaction on an electronic scale can be modeled with voltages and currents in classical circuit models, where the major challenges lie in constructing accurate models, including the calculation of circuit parameters from static or quasi-static field problems.

Key publications:

1. A. Bernland, A. Luger, and M. Gustafsson. Sum rules and constraints on passive systems. *Journal of Physics A: Mathematical and Theoretical*, **44**(14), 145205–, 2011.
2. D. Sjöberg and C. Larsson. Cramér-Rao bounds for determination of permittivity and permeability in slabs. *IEEE Transactions on Microwave Theory and Techniques*, **59**(11), 2970–2977, 2011.
3. D. Sjöberg and C. Larsson. Opportunities and challenges in the characterization of composite materials in waveguides. *Radio Science*, **46**, RS0E19–, 2011.

Conferences: C9, C11, and C26

Technical reports: TEAT-7211–TEAT-7212

2.2 Electromagnetic scattering and design

Under this heading, the scattering problem is of central importance, that is, when a prescribed electromagnetic field interacts with a particular object (the scatterer), the task is to determine the scattered field. There is often a particular design goal associated with the scattering, for instance to minimize the scattering for all frequencies, maximize the transmission through a panel for a certain frequency band, or maximize the scattering in order to obtain the most information on the object.

The design of complex structures and systems to obtain the design goals relies on the combination of relatively simple physical models to assert the overall function, as well as general or highly devoted numerical codes to compute the specific details of the different constituents. Much of our work in this category is performed in collaboration with industry, who often supply the broader systems perspective.

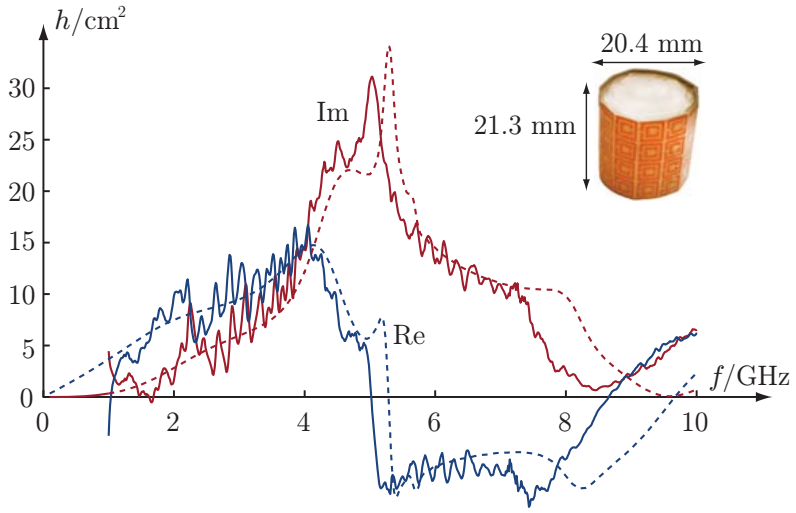


Figure 6: Example of a project under Section 2.2. Measured values (solid curves) and simulated values (dashed curves) for the forward scattering of a resonant structure on an ARLON CLTE-XT substrate supported by an expanded polystyrene cylinder.

Key publications:

1. A. Bernland, M. Gustafsson, and S. Nordebo. Physical limitations on the scattering of electromagnetic vector spherical waves. *Journal of Physics A: Mathematical and Theoretical*, **44**(14), 145401–, 2011.
2. M. Gustafsson and D. Sjöberg. Physical bounds and sum rules for high-impedance surfaces. *IEEE Transactions on Antennas and Propagatation*, **59**(6), 2196–2204, 2011.
3. A. Kazemzadeh. Nonmagnetic ultra wideband absorber with optimal thickness. *IEEE Transactions on Antennas and Propagation*, **59**(1), 135–140, 2011.
4. S. Nordebo, A. Bernland, M. Gustafsson, C. Sohl, and G. Kristensson. On the relation between optimal wideband matching and scattering of spherical waves. *IEEE Transactions on Antennas and Propagation*, **59**(9), 3358–3369, 2011.

Conferences: C12

Technical reports: TEAT-7211–TEAT-7213

2.3 Inverse scattering and imaging

In this category, the goal is to infer information on some object or structure using electromagnetic waves, including light. Depending on what is *a priori* known about

the object and scattering situation, different strategies may be employed. One alternative is to back propagate the measured field through a region which is known (usually air), as close as possible to the scatterer, and then see what equivalent currents this corresponds to. Another alternative is to set up several theoretical models of the scatterer, and see which one fits the measured data best. This usually results in computationally demanding algorithms.

A more specific set of problems is termed imaging. Here, the aim is to obtain an overall image of the scatterer, for instance its shape or location. This can sometimes be obtained in a relatively straightforward way from the scattering data, especially in the high frequency limit (ray optics).

Key publications:

1. C. Larsson, D. Sjöberg, and L. Elmkvist. Waveguide measurements of the permittivity and permeability at temperatures up to 1000 C. *IEEE Transactions on Instrumentation and Measurement*, **60**(8), 2872–2880, 2011.
2. S. Nordebo, M. Gustafsson, T. Sjöden, and F. Soldovieri. Data fusion for electromagnetic and electrical resistive tomography based on maximum likelihood. *International Journal of Geophysics*, pages 1–, 2011.
3. S. Nordebo, M. Gustafsson, and F. Soldovieri. Data fusion for reconstruction algorithms via different sensors in geophysical sensing. *Journal of Geophysics and Engineering*, **8**(3), S54–S60, 2011.

Conferences: C7–C8, and C22

2.4 Antennas and communication

In a wireless system, the antenna is the interface between the electric circuit and waves propagating in the surrounding medium. From a system point of view, the antenna suffers from several fundamental limitations in terms of available bandwidth, gain *etc.* versus, for instance, the available volume or complexity in the matching network. New antenna concepts such as MIMO (Multiple Input, Multiple Output) provide new opportunities for increased performance.

Our investigations of antennas and wireless systems concern sharpening of fundamental limitations of antennas in various circumstances. We also deal with higher levels of integration, for instance of the antenna with the amplifier or the matching network, or the antenna and the surrounding structure, including the interaction of the user. Simple, but yet accurate, methods of quantifying the performance of MIMO systems are investigated. Computational means of simulating the antenna and related structures are also developed.

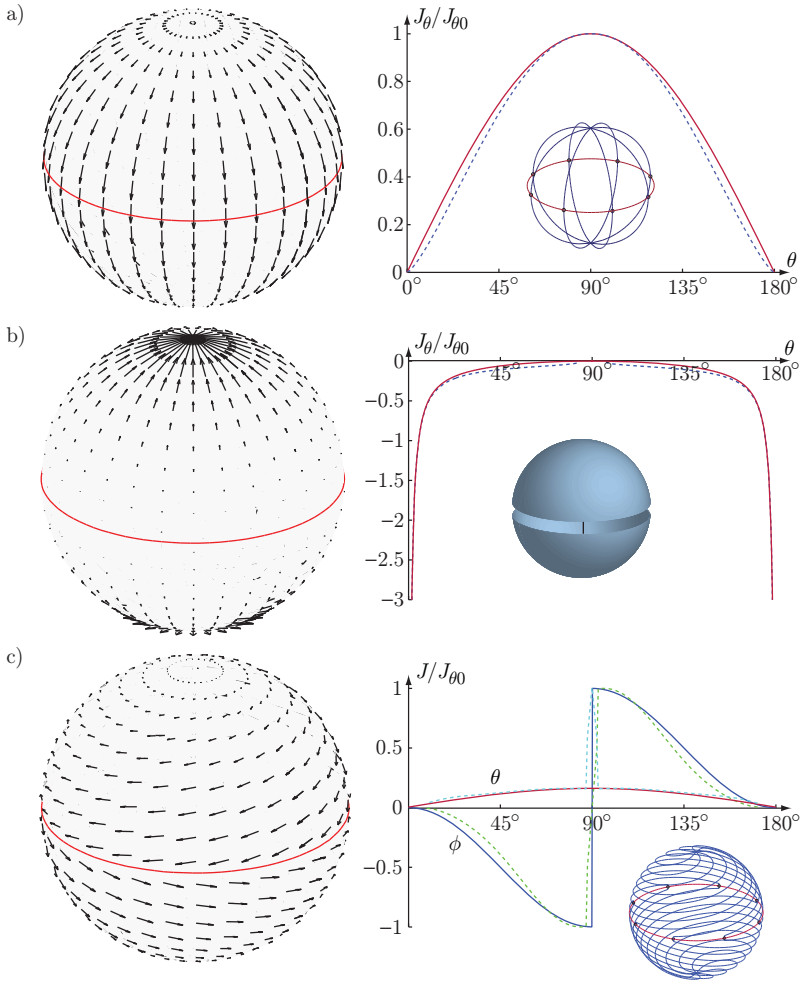


Figure 7: Example of a project under Section 2.4. Examples of current distributions on spheres with the charge density $\rho = \rho_0 \cos\theta$. a) folded spherical dipole with $\boldsymbol{J} \approx J_{\theta 0}\hat{\boldsymbol{\theta}} \sin\theta$. b) capped spherical dipole with $\boldsymbol{J} \approx J_{\theta 0}\hat{\boldsymbol{\theta}}(\sin\theta - 1/\sin\theta)$. c) folded spherical helix with $\boldsymbol{J} \approx J_{\theta 0}(0.15\hat{\boldsymbol{\theta}} \sin\theta - \hat{\boldsymbol{\phi}}\,\mathrm{sign}(\cos\theta)\sin^2\theta)$.

Key publications:

1. A. A. Glazunov, M. Gustafsson, and A. Molisch. On the physical limitations of the interaction of a spherical aperture and a random field. *IEEE Transactions on Antennas and Propagatation*, **59**(1), 119–128, 2011.
2. V. Plicanic, I. Vasilev, R. Tian, and B. K. Lau. Capacity maximisation of a handheld MIMO terminal with adaptive matching in an indoor environment. *Electronics Letters*, **47**(16), 900–901, 2011.
3. R. Tian, B. K. Lau, and Z. Ying. Multiplexing efficiency of MIMO antennas. *IEEE Antennas and Wireless Propagation Letters*, **10**, 183–186, 2011.

Conferences: C5–C6, C10, C13, C17–C21, C23–C24, and C31–C34

Technical reports: TEAT-7210

2.5 Accelerator engineering

This activity started in 2010. We then established collaborations with both Maxlab and ESS. In 2011 we started a project, financed by ESS, on the design of the drift tube linac of ESS. The DTL is located in the first part of the accelerator and accelerate the protons from 3 MeV to 80 MeV. The project is done in collaboration with INFN in Legnaro, Italy and involves one PhD student. We have also been involved in the beam position monitoring system for ESS and in investigations of the excitation and damping of higher order modes for both ESS and Maxlab.

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3 Dissertations, Published papers and Reports

3.1 Doctoral dissertations

Vanja Plicanic, "Characterization and enhancement of antenna system performance in compact MIMO terminals," June 14, 2011, see Figure 8.

Faculty opponent: Professor Ernst Bonek, Emeritus Professor at Vienna Technical University (TU Wien).

Figure 8: Left figure: Faculty opponent Professor Ernst Bonek (left) and respondent Vanja Plicanic (right) at Vanja's dissertation June 14, 2011.

Examining committee:

1) Assistant Professor Jon Wallace, Jacobs University Bremens, Germany
2) Professor Anja Skrivervik, Laboratory of Electromagnetics and Acoustics (LEMA), École Polytechnique Fédérale de Lausanne (EPFL)
3) Professor Jan Carlsson, Technical Research Institute of Sweden (SP), Sweden

3.1.1 Short presentation of Vanja Plicanic's thesis

Co-band multiple antenna implementation in realistic compact user terminals for downlink wireless communication is today considered a necessity for harvesting the potential of diversity and multiple input multiple output (MIMO) technology, thus achieving good coverage and high data rates and in the updated and new cellular communications systems. The recent rollouts of Long Term Evolution (LTE) around the world and thus the firm requirement on downlink MIMO technology in commercial compact user equipment (UE) such as smart phones, confirm the urgency of practical and optimal implementation of multiple antenna systems. However, the challenges of the implementation are not only limited to the antenna design and placement in the UE, but extend beyond the antenna and the common antenna parameters to comprise near field user interaction and propagation environment. Thus, it is the state of the overall communication channel that needs to be considered in design and characterization of the multiple antenna systems for compact UEs.

This doctoral thesis gives insights on the mechanisms behind the implementation of multiple antennas for diversity and MIMO gains in everyday user terminals with focus on the effects of compactness, user interaction and propagation channel on the implementation and, the communication channel and end user performances.

Furthermore, a topic of performance enhancement is naturally touched upon, with the purpose to ascertain the potential of the multiple antenna system design to be one of the key differentiator among different compact UEs.

3.2 Licentiate dissertations

Peter Johannesson, "A numerical hybrid method for microwave applications, based on hierarchical basis functions," June 15, 2011.

Reviewer: Associate Professor Thomas Rylander, Signals and Systems, Chalmers University, Göteborg, Sweden.

3.2.1 Short presentation of Peter Johannesson's thesis

Passive integrated components are crucial elements in integrated RF electronics. Planar monolithic inductors, for example, are used in frequency selective circuits such as tuned LNAs and VCOs. These inductors suffer from limited inductance values and limited quality values (Q-values). Another problem is the relatively large area the planar inductor consumes. It is thus of great interest to be able to compute these parameter values with high accuracy, optimizing the inductors and to be able to find new, more efficient, structures using standard desktop computers. It is also desirable that the results from the computations can be used to achieve a simple and accurate lumped-element model of the structure in order to enable complete circuit simulations of the circuits in which the structure is included. To fulfill the desired demands fast and accurate computational methods are needed. Using standard methods imply a vast number of unknowns, especially if the stratified substrate, beneath the inductor, is included. This leads to time demanding problems which only can be solved on very powerful computers. This is not in agreement with the desirable demands.

In this thesis a hybrid formulation is proposed for passive integrated components. The method is based on the finite element method (FEM) and the method of moment (MoM) combined with a representation based on a set of higher order hierarchical Legendre basis functions. The FEM is adopted to solve the fields in an interior domain, containing all conductive elements, and the MoM is adopted to achieve exact boundary conditions on the boundary to the interior domain. This means that the exterior domain is not explicitly included in the computations, which significantly reduces the complexity and the size of the problem. The FEM is a natural choice which enables the interior domain to be inhomogeneous. The stratified substrate is implicitly included in the formulation by applying a problem based Green's functions which is a natural part in the MoM. The representation based on the higher order hierarchical Legendre basis functions is applied since it, under certain circumstances, significantly reduces the number of unknowns.

3.3 Journal publications

J1. A. Bernland, M. Gustafsson, and S. Nordebo. Physical limitations on the scattering of electromagnetic vector spherical waves. *Journal of Physics A: Mathematical and Theoretical*, **44**(14), 145401–, 2011.

J2. A. Bernland, A. Luger, and M. Gustafsson. Sum rules and constraints on passive systems. *Journal of Physics A: Mathematical and Theoretical*, **44**(14), 145205–, 2011.

J3. A. A. Glazunov, M. Gustafsson, and A. Molisch. On the physical limitations of the interaction of a spherical aperture and a random field. *IEEE Transactions on Antennas and Propagatation*, **59**(1), 119–128, 2011.

J4. M. Gustafsson and D. Sjöberg. Physical bounds and sum rules for high-impedance surfaces. *IEEE Transactions on Antennas and Propagatation*, **59**(6), 2196–2204, 2011.

J5. X. Hou, C. Yang, and B. K. Lau. Impact of non-orthogonal training on performance of downlink base station cooperative transmission. *IEEE Transactions on Vehicular Technology*, **60**(9), 4533–4639, 2011.

J6. A. Ioannidis. On the cavity problem for the general linear medium in Electromagnetic Theory. *Bulletin of the Greek Mathematical Society*, **57**, 199–, 2011.

J7. A. Kazemzadeh. Nonmagnetic ultra wideband absorber with optimal thickness. *IEEE Transactions on Antennas and Propagation*, **59**(1), 135–140, 2011.

J8. G. I. Kiani, L. G. Olsson, A. Karlsson, K. P. Esselle, and M. Nilsson. Cross-Dipole Bandpass Frequency Selective Surface for Energy-Saving Glass Used in Buildings. *IEEE Transactions on Antennas and Propagation*, **59**(2), 520–525, 2011.

J9. C. Larsson, D. Sjöberg, and L. Elmkvist. Waveguide measurements of the permittivity and permeability at temperatures up to 1000 C. *IEEE Transactions on Instrumentation and Measurement*, **60**(8), 2872–2880, 2011.

J10. S. Nordebo, A. Bernland, M. Gustafsson, C. Sohl, and G. Kristensson. On the relation between optimal wideband matching and scattering of spherical waves. *IEEE Transactions on Antennas and Propagation*, **59**(9), 3358–3369, 2011.

J11. S. Nordebo, M. Gustafsson, T. Sjöden, and F. Soldovieri. Data fusion for electromagnetic and electrical resistive tomography based on maximum likelihood. *International Journal of Geophysics*, pages 1–, 2011.

J12. S. Nordebo, M. Gustafsson, and F. Soldovieri. Data fusion for reconstruction algorithms via different sensors in geophysical sensing. *Journal of Geophysics and Engineering*, **8**(3), S54–S60, 2011.

J13. V. Plicanic, I. Vasilev, R. Tian, and B. K. Lau. Capacity maximisation of a handheld MIMO terminal with adaptive matching in an indoor environment. *Electronics Letters*, **47**(16), 900–901, 2011.

J14. D. Sjöberg and C. Larsson. Cramér-Rao bounds for determination of permittivity and permeability in slabs. *IEEE Transactions on Microwave Theory and Techniques*, **59**(11), 2970–2977, 2011.

J15. D. Sjöberg and C. Larsson. Opportunities and challenges in the characterization of composite materials in waveguides. *Radio Science*, **46**, RS0E19–, 2011.

J16. J. C.-E. Sten and D. Sjöberg. Low-frequency scattering analysis and homogenisation of split-ring elements. *Progress in Electromagnetics Research B*, **35**, 187–, 2011.

J17. R. Tian, B. K. Lau, and Z. Ying. Multiplexing efficiency of MIMO antennas. *IEEE Antennas and Wireless Propagation Letters*, **10**, 183–186, 2011.

3.4 Contributions in books

CB1. B. K. Lau. Multiple antenna terminals. In *MIMO: From Theory to Implementation*, pages 267–298. San Diego: Academic Press, 2011.

3.5 Conference publications

C1. A. Bernland. On physical limitations for broadband electromagnetic scattering — high order spherical waves. 10th International Conference on Mathematical and Numerical Aspects of Waves, 2011-07-25/2011-07-29, The Pacific Institute for the Mathematical Sciences, Canada, 2011.

C2. A. Bernland, A. Luger, and M. Gustafsson. Using Herglotz representations to derive limitations on passive physical systems. 7th International Congress on Industrial and Applied Mathematics, 2011-07-18/2011-07-22, 2011.

C3. A. Derneryd, U. M. Khan, A. A. Kishk, M. Milutinovic, and P. Persson. Dual-polarized dielectric resonator antennas for base station applications. pages 630–634. EuCAP 2011: 5th European Conference on Antennas and Propagation, Rome, Italy, April 11–15 2011, 2011.

C4. X. Gao, A. A. Glazunov, J. Weng, C. Fang, J. Zhang, and F. Tufvesson. Channel measurement and characterization of interference between residential femto-cell systems. EuCAP 2011: 5th European Conference on Antennas and Propagation, 2011-04-11/2011-04-15, 2011.

C5. X. Gao, B. K. Lau, X. Wang, and T. Bolin. On simplifying WINNER II channel model for MIMO OTA performance evaluation. European Conference on Antennas and Propagation (EuCAP), 2011-04-11/2011-04-15, 2011.

C6. M. Gustafsson. Physical bounds on antennas of arbitrary shape. 2011 Loughborough Antennas & Propagation Conference, 2011-11-14, 2011.

C7. M. Gustafsson and S. Nordebo. Fisher information in inverse scattering. The 29th Progress In Electromagnetics Research Symposium, 2011-03-20, 2011.

C8. M. Gustafsson, S. Nordebo, J. Dumoulin, A. Perrone, S. Pignatti, and F. Soldovieri. Infrastructure surveillance by electromagnetic sensing. TAMSEC, 2011-11-20, 2011.

C9. M. Gustafsson and D. Sjöberg. Constraints on the temporal dispersion of passive metamaterials. URSI General Assembly, 2011-08-13, 2011.

C10. M. Gustafsson and D. Sjöberg. On the radiation resistance for small capacitive dipole antennas. The 5th European Conference on Antennas and Propagation (EuCAP), 2011-04-11, 2011.

C11. M. Gustafsson and D. Sjöberg. Sum rules and physical limitations for passive metamaterials. Metamaterials 2011: The Fifth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, 2011-10-10, 2011.

C12. M. Gustafsson, D. Sjöberg, and I. Vakili. On the extraordinary transmission through sub-wavelength apertures in perfectly conducting sheets. International Conference on Electromagnetics in Advanced Applications (ICEAA 2011), 2011-09-12, 2011.

C13. M. A. Jensen, B. K. Lau, J. Medbo, and J. Furuskog. Performance of cooperative MIMO based on measured urban channel data. European Conference on Antennas and Propagation (EuCAP), 2011-04-11/2011-04-15, 2011.

C14. C. Larsson and J. Jersblad. Near-field SAR for signature and camouflage evalutaion in realistic backgrounds. Antenna measurements techniques association 33rd annual symposium, 2011-10-16, AMTA, 2011.

C15. C. Larsson, S. E. B. Keskin, M. Gustafsson, G. Kristensson, D. Sjöberg, C. Sohl, and I. Vakili. Scattering measurements in a parallel plate waveguide: first results. URSI General Assembly, 2011-08-13, 2011.

C16. C. Larsson and D. Sjöberg. Accuracy of high temperature waveguide measurements. PIERS 2011, 2011-03-20, 2011.

C17. B. K. Lau and Z. Ying. Antenna design challenges and solutions for compact MIMO terminals. IEEE International Workshop on Antenna Technology (IWAT), 2011-03-07/2011-03-09, 2011.

C18. H. Li, B. K. Lau, and S. He. Angle and polarization diversity in compact dual-antenna terminals with chassis excitation. XXXth URSI General Assembly, 2011-08-13/2011-08-20, 2011.

C19. H. Li, B. K. Lau, and S. He. Design of compact MIMO terminal antennas using diversity mechanisms in the presence of chassis excitation. COST IC1004, TD(11) 02052, 2011-10-19/2011-10-21, 2011.

C20. H. Li, B. K. Lau, Y. Tan, S. He, and Z. Ying. Impact of current localization on the performance of compact MIMO antennas. European Conference on Antennas and Propagation (EuCAP), 2011-04-11/2011-04-15, 2011.

C21. H. Li, B. K. Lau, and Z. Ying. Optimal multiple antenna design for compact MIMO terminals with ground plane excitation. IEEE International Workshop on Antenna Technology (IWAT), 2011-03-07/2011-03-09, 2011.

C22. S. Nordebo, M. Gustafsson, and F. Soldovieri. Tunnel detection based on data fusion with radio frequency and electrical resistive tomography. EGU General Assembly 2011, 2011-04-07, 2011.

C23. V. Plicanic, B. K. Lau, and H. Asplund. Experimental evaluation of MIMO terminal antenna configurations in noise- and interference-limited urban scenarios. European Conference on Antennas and Propagation (EuCAP), 2011-04-11/2011-04-15, 2011.

C24. V. Plicanic, I. Vasilev, R. Tian, and B. K. Lau. Adaptive matching for capacity maximization of compact MIMO antennas in a measured office environment. COST IC1004, TD(11) 02054, 2011-10-19/2011-10-21, 2011.

C25. D. Sjöberg and M. Gustafsson. On the quality factor of a low-loss parallel-plate resonator based on complementary metamaterials. URSI General Assembly, 2011-08-13-/2011-08-20, 2011.

C26. D. Sjöberg and C. Larsson. Characterization of electromagnetic wave properties for complex materials and their interpretation as material parameters. National Radio Science Meeting, 2011-01-05, 2011.

C27. C. Sohl. On the change in electrostatic potential energy due to the introduction of an additional conductor. URSI General Assembly, 2011-08-13, 2011.

C28. C. Sohl, M. Gustafsson, G. Kristensson, D. Lovric, M. Nilsson, and A. Sunesson. Electrostatic measurements of low capacitance changes in a parallel plate capacitor. URSI General Assembly, 2011-08-13, 2011.

C29. C. Sohl and M. Törmänen. Kulturella skillnader i studenters syn på plagiering och otillåtet samarbete. 3:e Utvecklingskonferensen får Sveriges ingenjörsutbildningar, 2011-11-30/2011-12-01, 2011.

C30. C. Sohl and M. Törmänen. Är studenters syn på plagiering och otillåtet samarbete kulturellt betingad? Lunds universitets tredje utvecklingskonferens, 2011-10-13, 2011.

C31. R. Tian and B. K. Lau. Degree-of-freedom evaluation of six-port antenna arrays in a rich scattering environment. IEEE International Symposium on Antennas and Propagation, 2011-07-03/2011-07-08, IEEE, 2011.

C32. R. Tian, B. K. Lau, and Z. Ying. Multiplexing efficiency of multiple antenna systems. COST IC1004, TD(11) 01025, 2011-06-20/2011-06-21, 2011.

C33. S. Zhang, B. K. Lau, A. Sunesson, and S. He. Closely located dual PIFAs with T-slot induced high isolation for MIMO terminals. IEEE International Symposium on Antennas and Propagation, 2011-07-03/2011-07-08, IEEE, 2011.

C34. S. Zhang, B. K. Lau, A. Sunesson, and S. He. T-shape slot induced decoupling for closely spaced dual PIFAs in MIMO terminals. 1st COST IC1004 Scientific Meeting, 2011-06-20/2011-06-21, 2011.

3.6 Thesis publications

T1. V. Plicanic. *Characterization and Enhancement of Antenna System Performance in Compact MIMO Terminals.* PhD thesis, 2011.

T2. P. Johannesson. *A numerical hybrid method for microwave applications, based on hierarchical basis functions.* Licentiate thesis, Lund University, 2011.

3.7 Diploma works

The diploma works listed below can be downloaded from our web-page with address: **www.eit.lth.se**

D1. Olivia Karlberg, "Excitation of of higher order modes in an elliptical cavity."
Advisor: Anders Karlsson

D2. Shengyan Yan, "Analysis of Uplink Multi-Cell Closed Loop Power Control with Imperfect Channel Knowledge".
Advisors: Vincent Kotzsch and Michael Grieger, TU Dresden, Germany
Examiner: Buon Kiong Lau

D3. Davor Lovric, "Theoretical and experimental studies of polarizability dyadics".
Advisors: Mats Gustafsson and Christian Sohl
Examiner: Anders Sunesson

D4. Jonas Långbacka, "Design and evaluation of a dielectric multi-mode antenna array for MIMO applications".
Advisor: Thomas Bolin, Sony Ericsson Mobile Communications AB
Examiner: Buon Kiong Lau

D5. Bo Wu, "Polarization and multi-sector cooperative MIMO in a measured urban macrocellular environment".
Advisor: Buon Kiong Lau
Examiner: John B. Anderson

D6. Robin Johansson, "Implementation and development of a gradient shape optimization method for antennas."
Advisor: Johan Wettergren, RUAG AB
Examiner: Daniel Sjöberg

D7. Karol Krakowiak and Garsivaz Rafieian, "Experimental investigation of physical bounds on linearly polarized antennas."
Advisor: Mats Gustafsson
Examiner: Anders Sunesson

3.8 Technical reports

The technical reports listed below can be downloaded from our web-page with address: **www.eit.lth.se**

TR1. Peter Johannesson, "Higher order hierarchical H(curl) Legendre basis functions applied in the finite element method: emphasis on microwave circuits," *LUTEDX/(TEAT-7205)/1-11/(2011).*
Abstract: In this paper a set of higher order hierarchical H(curl) Legendre basis functions is introduced as a basis in the two and three dimensional finite element method (FEM). The basis functions are divided into three different sets: edge functions, surface functions and interior functions. Two problems are addressed in order to study the p-convergence of the representation. In the first problem the eigenvalues of an inhomogeneous rectangular waveguide with a rectangular inclusion are computed. The p-convergence is measured for a dielectric inclusion and for an inclusion with finite conductivity, respectively. In the second problem the eigenvalues of a homogeneous cubic cavity are computed in order to measure the p-convergence for the three dimensional representation.

TR2. Peter Johannesson and Anders Karlsson, "Numerical evaluation of potential integrals containing higher order hierarchical H(div) Legendre basis functions for parameterized quadrilateral surface cells,"
LUTEDX/(TEAT-7206)/1-19/(2011).
Abstract: The singularity cancelation scheme initially introduced by Khayat and Wilton for evaluating singular and near-singular potential integrals with $1/R$ singularities has in this paper been applied to parameterized quadrilateral cells containing higher order hierarchical H(div) Legendre basis functions. The singular and near-singular potential integrals treated in this paper appear in the method of moment (MoM). Numerical results are presented for different order numbers of the Legendre polynomials and for quadrilateral cells of different shapes.

TR3. Peter Johannesson, "Higher order hierarchical H(curl) and H(div) Legendre basis functions applied in hybrid FEM-MoM,"
LUTEDX/(TEAT-7207)/1-10/(2011).
Abstract: A hybrid finite element method/method of moments (FEM/MoM) technique is used to analyze the performance of higher order hierarchical Legendre basis functions. The FEM is used to model the interior part of the computational domain and the MoM is used to model the boundaries. Higher order hierarchical H(curl) Legendre basis functions have been applied to represent the electric field in the three

dimensional FEM and higher order hierarchical $H(\mathrm{div})$ Legendre basis functions have been applied to represent the electric and magnetic surface current densities in the MoM. The basis functions have been developed for hexahedral volume elements and quadrilateral surface elements, respectively. Numerical results are presented for the bistatic RCS of a dielectric cube for which the number of cells and the order numbers of the polynomials are varied.

TR4. Peter Johannesson and Anders Karlsson, "A quasi static iterative method for inductor parameter,"
LUTEDX/(TEAT-7208)/1-5/(2011).
Abstract: A low frequency algorithm designated for the calculation of the magnetic and the electric energies and the ohmic losses of passive components has been developed. These quantities can be used to achieve the inductance, the capacitance, the resistance, and the Q-value of the inductor at low frequencies. The method is based on an iterative scheme in which the different fields, such as the electric potential, Φ, and the vector potential, $\boldsymbol{A}$, are expanded in power series in ω. When the power series expansions are inserted into the quasi static Maxwell equations, *i.e.*, a low frequency approximation, it is possible to formulate the full problem in a set of differential equations in which the power series coefficients are the unknowns.

TR5. Peter Johannesson, "On the evaluation of impedance matrix terms in MoM: emphasis on capacitive couplings,"
LUTEDX/(TEAT-7209)/1-9/(2011).
Abstract: A method based on power series expansions of the surface charge density, with Legendre polynomials as basis functions, is introduced in this paper. With a Galerkin method, applied to the method of moment, the resulting integrals for the elements of the impedance matrix are four dimensional. The corresponding integrands are products of the static Green function and Legendre polynomials. The introduction of the Legendre polynomials leads to a reduction of the number of non-zero elements in the impedance matrix with a fast computational method as a consequence. The method is compared to standard MoM in which piecewise linear basis functions are used.

TR6. Mats Gustafsson, Marius Cismasu, and B.L.G. Jonsson, "Physical Bounds and Optimal Currents on Antennas,"
LUTEDX/(TEAT-7210)/1-22/(2011).
Abstract: Physical bounds on the directivity Q-factor quotient and optimal current distributions are determined for antennas of arbitrary shape and size using an optimization formulation. A variational approach offers closed form solutions for small antennas expressed in the polarizability of the antenna structure. Finite sized antennas are solved using Lagrangian parameters in a method of moments formulation. It is also shown that the considered stored electric energy can be negative for electrically large objects. This effect is mitigated by a Helmholtz decomposition of the current density. Moreover, it is shown that the optimal charge density for a small antenna can be generated by several current densities. Numerical examples for small and large antennas are used to illustrate the results.

TR7. Sven Nordebo, Börje Nilsson, Thomas Biro, Gökhan Cinar, Mats Gustafsson, Stefan Gustafsson, Anders Karlsson, and Mats Sjöberg, "Electromagnetic dispersion modeling and measurements for HVDC power cables," *LUTEDX/(TEAT-7211)/1-32/(2011)*.

Abstract: This paper provides a general framework for electromagnetic modeling, computation and measurements regarding the wave propagation characteristics of High-Voltage Direct Current (HVDC) power cables. The modeling is focused on very long (10 km or more) HVDC power cables and the relevant frequency range is therefore in the low-frequency regime of about 0–100 kHz. An exact dispersion relation is formulated together with a discussion on practical aspects regarding the computation of the propagation constant and the related characteristic impedance. Experimental time-domain measurement data from an 80 km long HVDC power cable is used to validate the model. It is concluded that a single-mode transmission line model is not adequate to account for the mismatch between the power cable and the instrumentation. A mismatch calibration procedure is therefore devised to account for the connection between the measurement equipment and the cable. A dispersion model is thus obtained that is accurate for early times of pulse arrival. To highlight the potential of accurate electromagnetic modeling, an example of high-resolution length-estimation is discussed and analyzed using statistical methods based on the Cramér-Rao lower bound. The analysis reveals that the estimation accuracy based on the present model (and its related model error) is in the order of 100 m for an 80 km long power cable, and that the potential accuracy using a "perfect" model based on the given measurement data is in the order of centimeters.

TR8. Sven Nordebo, Börje Nilsson, Thomas Biro, Gökhan Cinar, Mats Gustafsson, Stefan Gustafsson, Anders Karlsson, and Mats Sjöberg, "Electromagnetic dispersion modeling and measurements for HVDC power cables," *LUTEDX/(TEAT-7212)/1-20/(2011)*.

Abstract: This paper provides an exact asymptotic analysis regarding the low-frequency dispersion characteristics of the multi-layered coaxial cable. A layer-recursive description of the dispersion relation is derived and analyzed. It is shown that if there is one isolating layer and a perfectly conducting outer shield, the classical Weierstrass preparation theorem can be used to prove that the low-frequency behavior of the propagation constant is governed by a square root of the complex frequency, and an exact analytical expression for the dominating term of the asymptotic expansion is derived. It is furthermore shown that the same asymptotic expansion is valid to its lowest order even if the outer shield has finite conductivity and there is an infinite exterior region with finite non-zero conductivity. The proofs are based on asymptotic analysis, and illustrated with numerical examples. As a practical application of the theory, a High-Voltage Direct Current (HVDC) power cable is analyzed and a numerical solution to the dispersion relation is validated by comparisons with the asymptotic analysis. The comparison reveals that the low-frequency dispersion characteristics of the power cable is very complicated and a first order asymptotic approximation is valid only at extremely low frequencies (below 1 Hz). Hence, for practical modeling purposes such as with fault localization etc., an accurate numerical solution to the dispersion relation is of great value.

TR9. Mats Gustafsson, Iman Vakili, Sena E. Bayer, Daniel Sjöberg, Christer Larsson, "Optical theorem and forward scattering sum rule for periodic structures," *LUTEDX/(TEAT-7213)/1-17/(2011).*

Abstract: Based on energy conservation, an optical theorem is constructed for a slab having an arbitrary periodic microstructure in a plane. A sum rule for low pass structures is derived using analytic properties of Herglotz functions based on causality and passivity. The sum rule relates the extinction cross section to the static polarizability per unit cell, and quantifies the interaction between the slab and electromagnetic fields possible over all wavelengths. The results are illustrated with several numerical and experimental examples.

TR10. Anders Bernland, "Bandwidth limitations for scattering of higher order electromagnetic spherical waves with implications for the antenna scattering matrix," *LUTEDX/(TEAT-7214)/1-23/(2011).*

Abstract: Various physical limitations in electromagnetic theory and antenna theory have received considerable attention recently. However, there are no previous limitations on the scattering of higher order electromagnetic vector spherical waves, despite the widespread use of spherical wave decompositions. In the present paper, bandwidth limitations on the scattering matrix are derived for a wide class of heterogeneous objects, in terms of their electrical size, shape and static material properties. In particular, it is seen that the order of the dominating term in the Rayleigh limit increases with the order of the spherical wave. Furthermore, it is shown how the limitations place bounds on the antenna scattering matrix, thus introducing a new approach to physical limitations on antennas. Comparisons to other types of antenna limitations are given, and numerical simulations for two folded spherical helix antennas and a directive Yagi-Uda antenna are included to illuminate and validate the theory. The results in this paper are derived using a general approach to derive limitations for passive systems: First, the low-frequency asymptotic expansion of the scattering matrix of a general scatterer is derived. This gives a set of sum rules, from which the limitations follow.

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4 Guests and Seminars

4.1 Visitors at the group of Electromagnetic Theory

Curt Eidefeldt, The Swedish Defence Materiel Administration, FMV, Stockholm, Sweden, June 27, 2011.

Peter Greis, Saab Aeronautics, Linköping, Sweden, September 8, 2011.

Magnus Herberthson, Swedish Defence Research Agency, FOI, Linköping, Sweden, May 6, 2011.

Xueying Hou, Beihang University, P. R. China, April 26–28, 2011.

Anders Höök, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, January 31, April 18, May 24, September 8, 2011.

Hanna Isaksson, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, January 31, May 24, September 8, 2011.

Michael A. Jensen, Brigham Young University, USA, September 26-30, 2011.

Peter Karlsson, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, January 31, May 24, 2011.

Stefan Kröll, Division of Atomic Physics, Department of Physics, LTH, Lund, Sweden, August 26, 2011.

Sven Nordholm, Curtin University of Technology, Australia, October 26, 2011.

Thomas Rylander, Department of Signals and Systems, Chalmers University of Technology, Göteborg, Sweden, June 15, 2011.

Mahmood Sabooni, Division of Atomic Physics, Department of Physics, LTH, Lund, Sweden, August 26, September 5, September 9, September 15, 2011.

Rebecca Seviour, Lancaster University, UK, March 4, 2012.

Daniel D. Stancil, North Carolina State University, USA, November 29–December 1, 2011.

Elisabeth Stenquist, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, September 8, 2011.

David Wall, Department of Mathematics and Statistics, University of Canterbury, Christchurch, New Zealand, May 13–16, 2011.

Björn Widenberg, Applied Composites AB, Linköping, Sweden, January 24–25, April 18, September 8–9, November 17–18, December 15–16, 2011.

4.2 Seminars

Olivia Karlberg, Presentation of Diploma thesis, "Excitation of higher order modes in an elliptical cavity," January 20, 2011.

Shengyan Yan, Presentation of Diploma thesis, "Analysis of Uplink Multi-Cell Closed Loop Power Control with Imperfect Channel Knowledge," January 21, 2011.

Davor Lovric, Presentation of Diploma thesis, "Theoretical and experimental studies of polarizability dyadics," March 29, 2011.

Xueying Hou. Beihang University, P. R. China, "How Much Feedback Overhead is Required for Base Station Cooperative Transmission to Outperform Non-cooperative Transmission?" April 27, 2011.

Jonas Långbacka, Presentation of Diploma thesis, "Design and evaluation of a dielectric multi-mode antenna array for MIMO applications," May 4, 2011

Bo Wu, Presentation of Diploma thesis, "Polarization and multi-sector cooperative MIMO in a measured urban macrocellular environment," June 15, 2011.

Sven Nordholm, Curtin University of Technology, Australia, "Hearing Protection and Speech Communication in Industrial Environments", October 26, 2011.

Daniel D. Stancil, North Carolina State University, USA, "Distribution of wireless signals through HVC ducts; Precise localization of football using magneto sensors; Equalization in vehicular communications," November 30, 2011.

Robin Johansson, Presentation of Diploma thesis, "Implementation and development of a gradient shape optimization method for antennas," December 9, 2011.

4.2.1 Internal seminar series

Gerhard Kristensson, "The polarizability and the capacitance change of a bounded object in a parallel plate capacitor," January 14, 2011.

Christian Sohl, "A new theorem in electrostatics?" January 21, 2011.

Christer Larsson, "Discontinuites — Can they be characterized with measurements?," January 28, 2011.

Anders Sunesson, "Sampling strategies on Near Field Antenna Measurements," February 4, 2011.

Anders Bernland, "High order polarizabilities vs Waterman's static transition matrices — and then some Herglotz functions," February 11, 2011.

Mats Gustafsson, "Transmission coefficients and forward scattering sum rules," February 18, 2011.

Daniel Sjöberg, "Some static surprises," February 25, 2011.

Anders Melin, "Currents," March 4, 2011.

Marius Cismasu, "Stored Energies of Arbitrary Shaped Antennas," March 18, 2011.

Alexander Bondarik, "60 GHz Patch Antennas on Different Substrates," March 25, 2011.

Sven Nordebo, "Waves and signals on power lines," April 1, 2011.

Gerhard Kristensson, "The transit of Venus and the quest for the distance to the Sun (AU)," April 15, 2011.

Alireza Kazemzadeh, "THz absorbers," May 06, 2011.

Niklas Wellander, "On the calcium ion concentration dynamics in living cells," May 13, 2011.

Anders Karlsson, "Comsol 4.1," May 20, 2011.

Mats Gustafsson, "Extraordinary transmission," August 26, 2011.

Gerhard Kristensson, "Quaternions and rotations," September 2, 2011.

Marius Cismasu, "Advanced Computational Electromagnetics for Antenna Analysis, Industrial Antenna Design, Compact Antennas - Courses Attended at ESoA," September 9, 2011.

Daniel Sjöberg, "And now for something completely different: visualizing electromagnetic phenomena using python," September 16, 2011.

Marius Cismasu, "Advanced Computational Electromagnetics for Antenna Analysis, Industrial Antenna Design, Compact Antennas - Courses Attended at ESoA. Part 2," September 23, 2011.

Anders Bernland, "Direct Estimation of Spherical Wave Coefficients from Channel Measurements," September 30, 2011.

Anders Karlsson, "Determination of the fractal dimension of soot aggregates," October 7, 2011.

Alexander Bondarik, "60 GHz Patch Antennas Measurements," October 14, 2011.

Mats Gustafsson, "Infrastructure surveillance by electromagnetic sensing," October 21, 2011.

Sven Nordebo, "Electromagnetic dispersion modeling and measurements for HVDC power cables," October 27, 2011.

Christer Larsson, "Near-field SAR for Signature and Camouflage Evaluation in Realistic Backgrounds," November 4, 2011.

Daniel Sjöberg, "A volume integral equation for inverse scattering in waveguides," November 11, 2011.

Gerhard Kristensson, "Does the photon have a mass?" November 18, 2011.

Anders Sunesson, "Mobile phone antenna design directions," November 25, 2011.

Figure 9: Professors Ioannis Stratis and Athanassios Yannacopoulos outside the Department of Mathematics, Athens, Greece.

5 Visits and Lectures by the Staff

5.1 Visits to other institutes and departments

Anders Bernland:

Ericsson Research, Göteborg, Sweden, December 13, 2011.

Anders Derneryd:

SNRV (Swedish National Committee of URSI), annual meeting, Lund University, Sweden and Electrical Engineering Department of Electrical Engineering, Technical University of Denmark, Lyngby, Denmark, May 11–12, 2011.

Mats Gustafsson:

CNR in Tito, Italy. 5th ISTIMES WP4 meeting, February 4, 2011.

Kickoff NFFP5, Saab, Järfälla, Sweden, May 5, 2011.

IFSTTAR in Paris, France. 5th ISTIMES WP4 meeting, June 30–July 1, 2011.

Saab Aerosystems AB, Linköping, Sweden, August 2, 2011.

Antenna & Electromagnetics Research Group, School of Electronic Engineering and Computer Science, Queen Mary, University of London, UK, November 11, 2011.

School of Electrical Engineering, Electromagnetic Engineering, Royal Institute of Technology, Stockholm, Sweden, December 2, 2011.

Ericsson Research, Göteborg, Sweden, December 13, 2011.

Alireza Kazemzadeh:

FoT-meeting, IP3.3, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, June 28, 2011.

Department of Photonics Engineering, Technical University of Denmark (DTU), Lyngby, Denmark, April 12 and May 5, 2011.

Anders Karlsson:

INFN, Legnaro, Italy, December 15–16, 2011.

Gerhard Kristensson:

Meeting with the National Committees of Sweden, The Royal Swedish Academy of Sciences, Stockholm, Sweden, February 1, 2011.

SNRV (Swedish National Committee of URSI), annual meeting, Lund University, Sweden and Electrical Engineering Department of Electrical Engineering, Technical University of Denmark, Lyngby, Denmark, May 11–12, 2011.

Forskningens styrning, Kungl. Fysiografiska Sällskapet, Workshop, Lund, Sweden, May 17, 2011.

FoT-meeting, IP3.3, Saab Electronic Defence Systems (EDS), Mölndal, Sweden, June 28, 2011.

Popular science radio symposium to the memory of Östen Mäkitalos, "Mobiltelefoni i forntid, nutid och framtid," arranged by SNRV (Swedish National Committee of URSI), The Royal Swedish Academy of Sciences, Stockholm, Sweden, November 14, 2011.

SNRV (Swedish National Committee of URSI), autumn meeting, The Royal Swedish Academy of Sciences, Stockholm, Sweden, November 15, 2011.

Department of Mathematics, University of Athens, Greece, November 20–25, 2011, see Figure 9.

Buon Kiong Lau:

Wireless Communications Center (WCC), Universiti Teknologi Malaysia (UTM), Johor, Malaysia, January 3–7, 2011.

Tsinghua University and Beihang University, Beijing, China, July 18–22, 2011.

Department of Signal Processing, School of Engineering, Blekinge Institute of Technology (BTH), Sweden, December 16, 2011.

Daniel Sjöberg:

Project meeting (Micromodeling), FOI, Linköping, Sweden, March 9, 2011.

Project meeting (Micromodeling), FMV, Stockholm, Sweden, April 6, 2011.

NFFP5 kickoff, Saab EDS, Järfälla, Sweden, May 10, 2011.

Project meeting (Micromodeling), FOI, Linköping, Sweden, June 1, 2011.

RUAG AB, Göteborg, Sweden, June 16, 2011.

Project meeting (NFFP5), Saab Dynamics, Linköping, Sweden, June 22, 2011.

Project meeting (Multifunktionell perimeter), Electronic Defence Systems, Mölndal, Sweden, June 28, 2011.

Project meeting (Micromodeling), FOI, Linköping, Sweden, September 28, 2011.

Report meeting (Strategic Mobility), SSF, Stockholm, Sweden, October 3, 2011.

Report meeting, FMV, Stockholm, Sweden, October 26, 2011.

SP Borås, Sweden, November 8, 2011.

Project meeting (Multifunktionell perimeter), Saab Aeronautics, Linköping, Sweden, November 23, 2011.

Project meeting (NFFP5), Electronic Defence Systems, Mölndal, Sweden, December 19, 2011.

Project meeting (Micromodeling), FOI, Linköping, Sweden, December 20, 2011.

Christian Sohl:

Saab Electronic Defence Systems (EDS), Järfälla, Sweden, March 9–10, October 28, 2011.

Kickoff meeting luPOD, Hörby, Sweden, March 15–16, 2011.

Project meeting NFFP5, Saab Bofors Dynamics, Linköping, Sweden, June 22, 2011.

Saab Electronic Defence Systems (EDS), Mölndal, Sweden, October 4, November 3, November 10–11, 2011.

5.2 Guest Lectures by the department's staff

Anders Bernland:

Ericsson Research, Göteborg, Sweden. *Title of the talk:* "Antenna limitations based on spherical waves," December 13, 2011.

Mats Gustafsson:

School of Electronic Engineering and Computer Science Queen Mary, University of London, UK. *Title of the talk:* "An overview of physical bounds on antennas and metamaterials," November 11, 2011.

Ericsson Research, Göteborg, Sweden. *Title of the talk:* "Physical bounds on antennas," December 13, 2011.

Buon Kiong Lau:

Wireless Communications Center (WCC), Universiti Teknologi Malaysia (UTM), Malaysia. *Title of the talks:* (1) "Antenna Design for Multiple Antenna Terminals — Challenges and Solutions", (2) "Publish or Perish — surviving academic research", January 6, 2011.

5.3 Organization of Courses and Workshops

1. Sigma Flyg, Department of Electrical and Information Technology, Lund, Sweden, September 27, 2011.
   Program September 27:
   a) Jan Fagerström, *Title:* Termisk modellering av CUBI
   b) Lars Petersson, *Title:* Erfarenheter av IR-signaturmätningar vid Saab Dynamics
   c) Torleif Martin, *Title:* RCS metodik för gruppantenner
   d) Hanna Isaksson, *Title:* Luftburna lågfrekvenssensorer för detektion av stealthmål
   e) Mats Gustafsson, *Title:* Transmission and reflection for periodic structures
   f) Magnus Gustafsson, *Title:* Validering av Iterativ fysikalisk optik (IPO)
   g) Michael Andersson, *Title:* Rasorber - multifunktionell perimeter
   h) Christer Larsson, *Title:* Mätning av RCS på frekvenser under 2 GHz
   i) Bernard Gustafsson, *Title:* IRS beräkningar på Volvo Aero

Figure 10: Christian Sohl at his poster at the XXXth URSI General Assembly, Istanbul, Turkey.

2. The First Scientific Meeting of EU COST Action IC 1004 on "Cooperative Radio Communications for Green Smart Environments" (http://www.ic1004.org), Department of Electrical and Information Technology, Lund University, Lund, Sweden, June 20–21, 2011.
   The meeting was attended by 100 participants, with the majority from Europe and several from other parts of the world. There were about 60 oral presentations in the two-day meeting.

5.4 Participation in conferences and workshops

Anders Bernland:

Participated with an oral paper at the 7th International Congress on Industrial and Applied Mathematics, Vancouver, BC, Canada. *Title of the Paper:* "Using Herglotz representations to derive limitations on passive physical systems," July 18–22, 2011.

Participated with an oral paper at the 10th International Conference on Mathematical and Numerical Aspects of Waves, Vancouver, BC, Canada. *Title of the Paper:* "On physical limitations for broadband electromagnetic scattering — high order spherical waves," July 25–29, 2011.

Anders Derneryd:

Presented a paper at the 5th European Conference on Antennas and Propagation, Rome, Italy. *Title of the paper:* "Dual-polarized dielectric resonator antennas for base station applications," April 11–15, 2011.

Presented a paper at the 1st Scientific Meeting of COST Action IC 1004, Lund, Sweden. *Title of the paper:* "Multi-objective optimization of MIMO antennas for dual-band user devices," June 20–21, 2011.

Presented a paper at the IEEE AP-S Symposium & USNC/URSI Meeting, in Spokane, WA, USA. *Title of the paper:* "Multi-objective optimization of MIMO antennas for dual-band user devices," July 3–8, 2011.

Mats Gustafsson:

Participated with a poster in the fourth communication workshop on the Sino-Swedish Cooperative Program: IMT-Advanced and Beyond, Haitang Bay, Sanya, China. *Title of the poster:* "Performance limitations and array antennas for communication," March 9–13, 2011.

Participated with an invited oral paper at the Progress In Electromagnetics Research Symposium (PIERS 2011), Marrakech, Morocco. *Title of the paper:* "Fisher Information in Inverse Scattering," March 20–23, 2011.

Participated with an invited oral paper at the 5th European Conference on Antennas and Propagation, Rome, Italy. *Title of the paper:* "On the radiation resistance for small capacitive dipole antennas," April 11–15, 2011.

Participated in the Charmant workshop, Göteborg, Sweden. *Title of the presentation:* "Biomedical Applications of EM: Microwave Tomography," May 10, 2011.

Participated with an invited oral paper at the XXXth URSI General Assembly, Istanbul, Turkey. *Title of the paper:* "Constraints on the temporal dispersion of passive metamaterials", August 13–20, 2011.

Chairman of the XXXth URSI General Assembly, Istanbul, Turkey. *Title of the session:* "Electromagnetic Theory", August 13–20, 2011.

Participated with an invited oral paper at The thirteenth edition of the International Conference on Electromagnetics in Advanced Applications (ICEAA 2011), Torino, Italy. *Title of the paper:* "On the extraordinary transmission through sub-wavelength apertures in perfectly conducting sheets", September 12–16, 2011.

Participated in SigmaFlyg, Lund, Sweden. *Title of the presentation:* "Transmission and reflection for periodic structures", September 27, 2011.

Participated with an oral paper at Metamaterials '2011: The Fifth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Barcelona, Spain. *Title of the paper:* "Sum rules and physical limitations for passive metamaterials", October 10–15 2011.

Participated with an oral paper at The second National Symposium on Technology and Methodology for Security and Crisis Management (TAMSEC 2011), Linköping, Sweden. *Title of the paper:* "Infrastructure surveillance by electromagnetic sensing: The ISTIMES project," October 19–20, 2011.

Participated with an oral paper at the 2011 Loughborough Antennas & Propagation Conference (LAPC), Loughborough, UK. *Title of the paper:* "Physical bounds on antennas of arbitrary shape", November 14–15 2011.

Gerhard Kristensson:

Participated with an oral paper at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "The capacity change of a bounded object in a parallel plate capacitor," August 13–20, 2011.

Chairman at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Session:* "Electromagnetic Theory," August 13–20, 2011.

Christer Larsson:

Participated with an oral paper at the Progress In Electromagnetics Research Symposium (PIERS 2011), Marrakech, Morocco. *Title of the Paper:* " Accuracy of High Temperature Waveguide Measurements," March 20–23, 2011.

Participated with an oral paper at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "Scattering measurements in a parallel plate waveguide: first results," August 13–20, 2011.

Participated with an oral paper at the Antenna measurements techniques association 33rd annual symposium, Denver, Colorado, USA. *Title of the Paper:* "Near-field SAR for signature and camouflage evalutaion in realistic backgrounds," October 16–21, 2011.

Buon Kiong Lau:

Participated with a keynote paper and a poster paper at the IEEE International Workshop on Antenna Technology, Hong Kong, P. R. China. *Titles of the Papers:* "Antenna design challenges and solutions for compact MIMO terminals," and "Optimal multiple antenna design for compact MIMO terminals with ground plane excitation", March 7–9, 2011.

Participated with four oral papers at the 5th European Conference on Antennas and Propagation, Rome, Italy. *Titles of the Papers:* (1) "On simplifying

WINNER II channel model for MIMO OTA performance evaluation," (2) "Performance of cooperative MIMO based on measured urban channel data," (3) "Experimental evaluation of MIMO terminal antenna configurations in noise- and interference-limited urban scenarios," and (4) "Impact of current localization on the performance of compact MIMO antennas," April 11–15, 2011.

Session Co-Convener and Co-Chairman at the 5th European Conference on Antennas and Propagation, Rome, Italy. *Title of the Session:* Recent Advances in MIMO Systems: "Channel Characterization and Antenna-Channel Interactions," April 11–15, 2011.

Participated with two temporary documents at the First Scientific Meeting of COST IC1004, Lund, Sweden. *Titles of the TDs:* "Multiplexing efficiency of multiple antenna systems" and "T-shape slot induced decoupling for closely spaced dual PIFAs in MIMO terminals," June 20–21, 2011.

Participated with two oral papers at the IEEE International Symposium of Antennas and Propagation, Spokane, Washington, USA. *Titles of the Papers:* "Closely located dual PIFAs with T-slot induced high isolation for MIMO terminals," and "Degree-of-freedom evaluation of six-port antenna arrays in a rich scattering environment", July 3–8, 2011.

Session Chairman at the IEEE International Symposium of Antennas and Propagation, Spokane, Washington, USA. *Title of the Session:* "Antenna Design for MIMO Systems," July 3–8, 2011.

Participated with an oral paper at the XXXth URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "Angle and polarization diversity in compact dual-antenna terminals with chassis excitation," August 13–20, 2011.

Session Convener and Chairman at the XXXth URSI General Assembly, Istanbul, Turkey. *Title of the Session:* "Antenna Channel Interactions for Future Wireless Communications," 13–20 Aug. 2011.

Participated with two temporary documents (TDs) at the COST IC1004 2nd Management Committee Meeting, Lisbon, Portugal. *Titles of the TDs:* "Adaptive matching for capacity maximization of compact MIMO antennas in a measured office environment" and "Design of compact MIMO terminal antennas using diversity mechanisms in the presence of chassis excitation", October 19–21, 2011.

Daniel Sjöberg:

Participated in the NFFP seminar, Folkets hus, Stockholm, Sweden. May 4, 2011.

Participated with an oral presentation at the SAT-symposium, Försvarshögskolan, Stockholm. *Title of the presentation:* "Nya material — metamaterial", June 8, 2011.

Participated with an oral paper at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "On the quality factor of a low-loss parallel-plate resonator based on complementary metamaterials," August 13–20, 2011.

Participated with an oral presentation at the Sigma/epsilon/flyg symposium, Försvarshögskolan, Stockholm, *Title of the talk:* "Spridning för absorbentklädda cylindrar med cirkulärt tvärsnitt", September 27, 2011.

Christian Sohl:

Participated with an oral paper at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "Electrostatic measurements of low capacitance changes in a parallel plate capacitor," August 13–20, 2011.

Participated with a poster presentation at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "On the change in electrostatic potential energy due to the introduction of an additional conductor," August 13–20, 2011.

Participated with a poster presentation at Lunds universitets utvecklingskonferens, Lund, Sweden. *Title of the Paper:* "Är studenters syn på plagiering och otillåtet samarbete kulturellt betingad?," October 13, 2011.

Niklas Wellander:

Participated with an oral paper at the XXX$^{\text{th}}$ URSI General Assembly, Istanbul, Turkey. *Title of the Paper:* "Homogenization of a Nonlocal Electrostatic Equation," August 13–20, 2011.

5.5 Examination committees

Mats Gustafsson:

Member of the examination committee for Markus Johansson, Department of Signals and Systems, Chalmers University of Technology, Sweden. *Title of the thesis:* "Phase Retrieval Methods for Electromagnetic Source Modeling," February 28, 2011.

Member of the examination committee for Pu Zhang, Department of Electromagnetic Engineering, School of Electrical Engineering, Royal Institute of Technology, Stockholm, Sweden. *Title of the thesis:* "Theory of transformation optics and invisibility cloak design," May 5, 2011.

External reviewer of the Master thesis for Oscar Borries, Section for Scientific Computing, DTU Informatics, Technical University of Denmark. *Title of the thesis:* "Regularization Methods for Computation of Equivalent Sources," November 8, 2011

Substitute examination committee member for Ruiyuan Tian, Department of Electrical and Information Technology, Lund University, Sweden. *Title of the thesis:* "Design and Evaluation of Compact Multi-antennas for Efficient MIMO Communications," November 29, 2011.

Member of the examination committee for Erik Alerstam, Department of Physics, Lund University, Sweden. *Title of the thesis:* "Optical Spectroscopy of Turbid Media: Time-Domain Measurements and Accelerated Monte Carlo Modelling," December 16, 2011.

External reviewer of the Licentiate thesis for Oskar Talcoth, Department of Signals and Systems, Chalmers University of Technology, Sweden. *Title of the thesis:* "Electromagnetic modeling and design of medical implants and devices," December 19, 2011.

Gerhard Kristensson:

Chairman at the dissertation of Ruiyuan Tian, Department of Electrical and Information Technology, Lund University, Sweden. *Title of the thesis:* "Design and Evaluation of Compact Multi-antennas for Efficient MIMO Communications," November 29, 2011.

Buon Kiong Lau:

Faculty opponent for Muhammad Gufran Khan, Department of Signal Processing, School of Engineering, Blekinge Institute of Technology (BTH). *Title of thesis:* "On Modulation and Detection Schemes for Low-complexity Impulse Radio UWB Communications," December 16, 2011.

Daniel Sjöberg:

Substitute examination committee member for Rikard Ojala, Centre for Mathematical Sciences, Lund University. *Title of the thesis:* "Towards an all-embracing elliptic solver in 2D," December 2, 2011.

5.6 Referee for international journals and conferences

Anders Derneryd:

IET Electronics Letters

IET Proc. Microwaves, Antennas and Propagation

IEEE Transactions on Antenna and Propagation

IEEE Antennas and Wireless Propagation Letters

Progress in Electromagnetics Research Letters

41th European Microwave Conference (EuMC 2011)

Mats Gustafsson:

IEEE Antennas and Wireless Propagation Letters

IEEE Transactions on Antenna and Propagation

IEEE Geoscience and Remote Sensing Letters

XXX$^{\text{th}}$ URSI General Assembly.

The 20$^{\text{th}}$ European Conference on Circuit Theory and Design (ECCTD2011).

Anders Karlsson:

IEEE Transactions on Antenna and Propagation

J Electromagnetic Wave Applications

Int J of RF and Microwave Computer Aided Engineering

Gerhard Kristensson:

Wave Motion (as editor)

XXX$^{\text{th}}$ URSI General Assembly.

Christer Larsson:

IEEE Transactions on Antenna and Propagation

IEEE Antennas and Wireless Propagation Letters

Buon Kiong Lau:

IEEE Transactions on Antenna and Propagation

IEEE Transactions on Wireless Communications

IEEE Antennas and Propagation Magazine

Newcom++/COST 2100, Joint Workshop on Wireless Communications (JNCW 2011)

International Conference on Computer Communication Networks (ICCCN 2011)

Loughborough Antennas and Propagation Conference (LAPC 2011)

IEEE 74th Vehicular Technology Conference (VTC-Fall 2011)

5th European Conference on Antennas and Propagation (EuCAP 2011)

Daniel Sjöberg:

Radio Science (two times)

IEEE Trans. Antennas Propagation (four times)

5.7 Other activities

Christian Sohl:

Participated in the Lund Unviersity Postodoctoral Programme (luPOD).

Participated as a mentor in the Lund University Mentorship Programme for Engineering PhD Students (PLUME).

Participated in the course "Examination — utveckling av examinationspraxis genom aktionsforskning" during the spring, 2011.

Participated in the course "LTHs docentkurs" during the fall, 2011.

Daniel Sjöberg:

Popular lectures for high school students (NMT-föreläsningar), March 7–11, 2011.

Pedagogisk inspirationskurs moodle, March 25, 2011.

Participated in the PLUME program as mentor.

Participated as a member in the external review committee for undergraduate education at Aalto university, Electrical Engineering panel, April 11–15, 2011.

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6 Teaching Activities

6.1 Undergraduate teaching

The Electromagnetic Theory group gives courses in Circuit Theory and in Electromagnetic Field Theory. The students come from five educational programs: Engineering Physics (F), Electrical Engineering (E), Computer Science (D), Engineering Mathematics (Pi), and Engineering Nanoscience (N). In order to complete one of these programs the student must accomplish 300 ECTS credits, where one academic year corresponds to 60 ECTS credits. The nominal time to complete one of these programs is thus five years. The group also teaches courses in the international master programs Wireless Communication (MWIR) and Photonics (MFOT). An overview of the courses is presented in Figure 11.

6.1.1 Undergraduate courses given during 2011

Program[a]	**Name of the course**	**Lecturer**[b]
E1	Electronics	**Anders Karlsson**
		Alexander Bondarik
C2, D2	Signal Processing in Multimedia	Marius Cismasu
F2, N2	Electromagnetics and Electronics	**Richard Lundin**
		Anders Bernland
		Alexander Bondarik
		Marius Cismasu
		Anders Karlsson
E3	Electromagnetic Fields	**Richard Lundin**
E3	Engineering Aspects of an Application	Richard Lundin
F3	Electromagnetic Field Theory	**Christian Sohl**
		Anders Bernland
		Kristin Persson
Pi3	Electromagnetic Field Theory	**Christian Sohl**
		Anders Bernland
		Kristin Persson
E3	Electromagnetic Fields,	
	Advanced Course	**Richard Lundin**
E4, F4, Pi4,	Antenna Technology	**Mats Gustafsson**
MWIR1, MFOT1		Marius Cismasu
E4, F4, Pi4	Electromagnetic Wave Propagation	**Daniel Sjöberg**
		Marius Cismasu
E4, F4, Pi4	Microwave Theory	**Anders Karlsson**
D4, E4, C5,	Multiple Antenna Systems	**Buon Kiong Lau**
MWIR2		

[a] F1 = Engineering Physics, first year; E1 = Electrical Engineering, first year; D2 = Computer Science, second year *etc.*, MWIR = Master program in Wireless Communications, MFOT = Master program in Photonics.

[b] The examiner/lecturer is given in bold face. Only personnel in the group is listed if there has been teachers from other groups involved in the course.

6.1.2 A brief presentation of the courses

ESS010 Electronics (15 ECTS credits, 110 hours):
Given for the first year students of the Electrical Engineering, or E-, program. Approximately 100 students.
Course literature: Hambley, "Electric Engineering," Pearson, 2008; "Kretsteori, ellära och elektronik, exempelsamling," 2011.

ETE115 Electromagnetics and Electronics (7.5 ECTS credits, 62 hours):
Given for the second year students of the Engineering Physics and Engineering Nanoscience, or F- and N-, programs. Approximately 120 students.

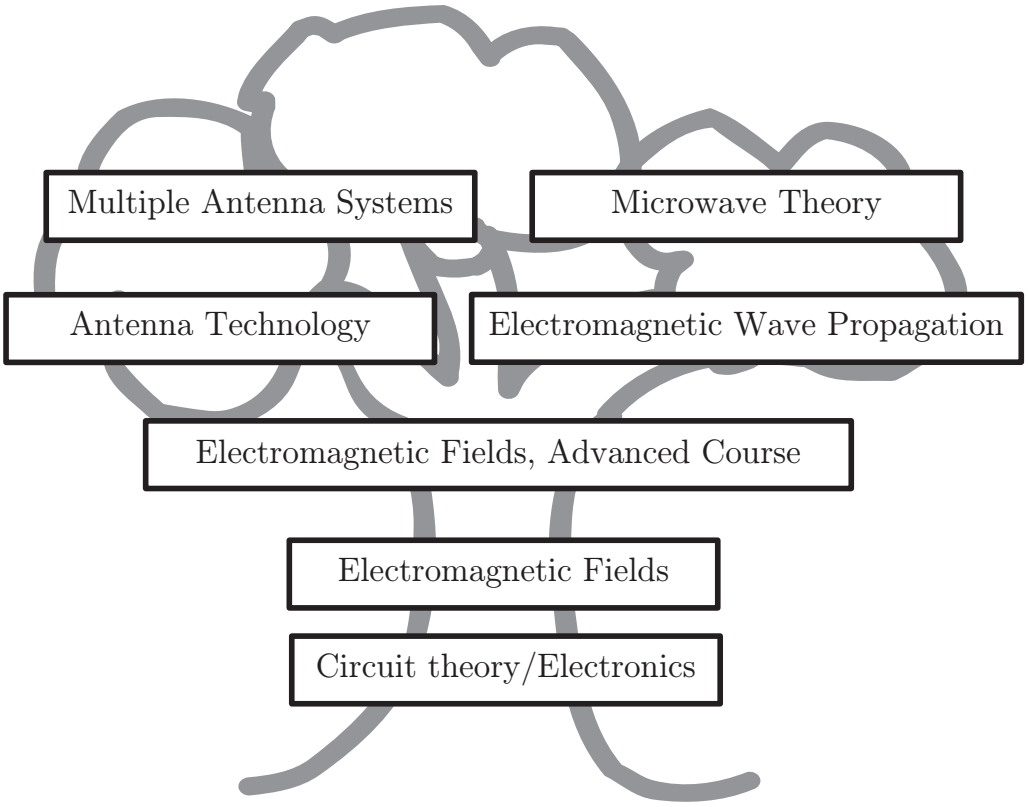

Figure 11: The undergraduate courses given by the Electromagnetic Theory group.

The course includes: Potential, voltage, current, voltage source, current source, resistor, Ohm's law, Kirchhoff's laws. Capacitors, inductors, differential equations, phasors, impedance, admittance, power. Node-voltage method, Thevenin and Norton equivalents. Transfer function, Bode diagram, filters. Diodes, field-effect transistors and operational amplifiers. Transmission line theory. Electrostatics. Magnetostatics. Maxwell's equations. Properties of materials. Laboratory sessions.
Course literature: D. Sjöberg and M. Gustafsson, "Kretsteori, ellära och elektronik," Dept. Electrical and Information Technology, Lund University, 2008; problem collection; "Kretsteori, ellära och elektronik, exempelsamling," 2011.

ESS050 Electromagnetic Fields (9 ECTS credits, 84 hours):
Given for the third year students of the Electrical Engineering, or E-, program. Approximately 60 students.
Vector analysis: Scalar fields and vector fields. Gradient, divergence and curl in Cartesian coordinates. Gauss's theorem and Stokes's theorem. Cylindrical coordinates. Spherical coordinates.
Quasi-stationary fields: Coulomb's law. Electrostatic fields in vacuum. Fields in the presence of dielectrics. Electric images. Current fields. Biot-Savart's law. Magnetostatic fields in vacuum. Magnetic fields in material media. Magnetic circuits.
General electromagnetic fields: The Maxwell equations. Plane waves. Retarded

potentials. Radiation fields from known sources and simple antennas. The Poynting vector.
Course literature: Popovic and Popovic, "Introductory Electromagnetics," Prentice-Hall, 2000; lecture notes; problem collection, KF Sigma 2002.

ETE055 Electromagnetic Field Theory (6 ECTS credits, 56 hours):
Given for the third year students of the Engineering Physics program. Approximately 90 students.
The course is an introductory course in the basic electro-static and magneto-static problems. It covers the basic laws such as the Coulomb's and Biot-Savart's laws. The latter part of the course covers the electromagnetic problems, the Poynting vector, and the Maxwell equations. Basic wave propagation problems, *i.e.*, plane waves, retarded potentials, and radiation fields from known sources and simple antennas are also part of this course.
Course literature: D. J. Griffiths, "Introduction to Electrodynamics," Prentice-Hall, 1999; problem collection, KF Sigma 2004.

ETEF01 Electromagnetic Field Theory (7 ECTS credits, 66 hours):
Given for the third year students of the Engineering Mathematics program. Approximately 40 students.
The course is an introductory course in the basic electro-static and magneto-static problems. It covers the basic laws such as the Coulomb's and Biot-Savart's laws. The latter part of the course covers the electromagnetic problems, the Poynting vector, and the Maxwell equations. Basic wave propagation problems, *i.e.*, plane waves, retarded potentials, and radiation fields from known sources and simple antennas are also part of this course.
Course literature: D. J. Griffiths, "Introduction to Electrodynamics," Prentice-Hall, 1999; problem collection, KF Sigma 2004.

ETI015 Electromagnetic Fields, Advanced Course (6 ECTS credits, 56 hours):
Given for the third year students of the Electrical Engineering, or E-, program. Approximately 15 students.
The course focuses on: transmission line theory, wave propagation in free space and conductive medium, rectangular metallic waveguides and antenna theory.
Course literature: Popovic and Popovic, "Introductory Electromagnetics," Prentice-Hall, 2000; lecture notes; problem collection, KF Sigma 2002.

ETEN10 Antenna technology (7.5 ECTS credits, 50 hours):
Given for the fourth year students of the Engineering Physics, Electrical Engineering, and Engineering Mathematics, or F-, E-, and Pi-programs, and the international master programs Wireless Communication (MWER) and Photonics (MFOT). Approximately 50 students.
Basic electromagnetic principles with applications to antenna design and analysis are treated in this course. A broad range of antenna types from single antenna elements to arrays of radiating elements and continuous sources are covered. Synthesis of radiation patterns is included as an integral part. The course gives a good

understanding and knowledge of various types of antennas, their characteristics and various applications. Three laboratory exercises have to be carried out. These involve computer simulation and measurements of antenna parameters.
Course literature: Kraus, J. D. and Marhefka, R., "Antennas". 3 ed., McGraw-Hill, 2002.

ETEN05 Electromagnetic Wave Propagation (7.5 ECTS credits, 46 hours):
Given for the fourth year students of the Engineering Physics, Electrical Engineering, and Engineering Mathematics, or F-, E-, and Pi-programs, and the international master program: Photonics. Approximately 15 students.
Basic electromagnetic wave propagation is described in this course. The emphasis is laid on the propagation properties of plane harmonic waves in homogeneous media. Other topics treated in some detail are: dispersion, reflection, transmission, and scattering in homogeneous and inhomogeneous (stratified) media.
Course literature: Sophocles J. Orfanidis: Electromagnetic Waves and Antennas, `http://www.ece.rutgers.edu/~orfanidi/ewa/`.

ETEN01 Microwave Theory (7.5 ECTS credits, 60 hours):
Given for the fourth year students of the Engineering Physics, the Engineering Mathematics, and the Electrical Engineering, or F-, Pi-, and E-, programs. Approximately 30 students.
A theoretical treatment, based upon the Maxwell equations, of wave propagation in guided structures is the basis for this project course. Three projects are performed, one of which is presented orally. The projects involve mathematical modeling and analysis as well as numerical treatment.
Course literature: A. Karlsson and G. Kristensson, "Microwave theory ," Lund, 2011.

EITN10 Multiple Antenna Systems (7.5 ECTS credits, 42 hours):
This course is given annually during the fall for second year students enrolled in the Wireless Communications Master Program. It is also open for students enrolled in other programs (D4, E4, C5, MWIR2). Approximately 20 students.
The aim of this course is to provide a comprehensive treatment of the area of multiple antenna systems for wireless communications. It begins with the theoretical aspects of multiple antenna or multiple-input-multiple-output (MIMO) systems, which predicts huge performance gains in comparison to conventional single antenna systems. The critical role of overall channel gain and correlation (e.g. influence of line-of-sight (LOS) component in a scenario) in MIMO system performance will be emphasized. The theoretical results provided the momentum for practical implementations, several aspects of which will be covered in the course.
Course literature: Paulraj A, Nabar R, and Gore D: Introduction to Space-Time Wireless Communications, Cambridge University Press, UK, 1996. ISBN 0-521-82615-2.

6.2 Diploma Works

See **3.7 Diploma Works**.

6.3 Development and revisions of teaching materials

Anders Karlsson, Gerhard Kristensson, and Christian Sohl:

Exempelsamling i Elektromagnetisk fältteori för F3 och Pi3. 2011.

Anders Karlsson:

Microwave theory. 2012.

6.4 Graduate courses

Buon Kiong Lau:

EITN10 Multiple Antenna Systems, 7.5 credits points, fall 2011.

Gerhard Kristensson:

EIT080F Vector Waves and Probe Compensation, 7.5 credit units, fall 2011.

6.5 External teaching

Buon Kiong Lau:

One of several lecturers at the full-day short course "The ABC of small antennas" at the 5th European Conference on Antennas and Propagation, Rome, Italy. *Title of the lecture:* "Design Strategies and Measurement of Small Antenna Arrays," April 11–15, 2011.

7 Official Commissions

7.1 Official scientific committees

Anders Derneryd:

Co-opted member of Section B of SNRV (Swedish National Committee of URSI).

Member of COST Action IC 1004 Cooperative Radio Communications for Green Smart Environments.

Mats Gustafsson:

Co-opted member of Section B of SNRV (Swedish National Committee of URSI).

Anders Karlsson:

Member of SNRV (Swedish National Committee of URSI).

Chairman of Commission B of SNRV (Swedish National Committee of URSI).

Official delegate of SNRV (Swedish National Committee of URSI) for Commission B.

Gerhard Kristensson:

Member of SNRV (Swedish National Committee of URSI).

Chairman of SNRV (Swedish National Committee of URSI).

Official Swedish delegate of URSI (Swedish National Committee of URSI).

Member of the Commission B Technical Advisory Board (B-TAB) of URSI Commission B.

Member of the Board of Editors of the international journal *Wave Motion*.

Member of the Editorial and Review Board of the international journal *Journal of Electromagnetic Waves and Applications* and the publication series *Progress in Electromagnetic Research*.

Fellow of the Institute of Physics, UK.

Member of "Kungl. Fysiografiska Sällskapet i Lund".

Convener of the Section of Applied Sciences, "Kungl. Fysiografiska Sällskapet i Lund".

Board member of "Kungl. Fysiografiska Sällskapet i Lund".

Buon Kiong Lau:

Co-opted member of Section C of SNRV (Swedish National Committee of URSI).

Member of Education Committee, Antennas and Propagation Society, the Institution of Electrical and Electronics Engineers (IEEE).

Technical Program Committee (TPC) Member of the Loughborough Antennas and Propagation Conference (LAPC), Loughborough, UK, November 14-15, 2011.

TPC Member of the IEEE 74th Vehicular Technology Conference (VTC) — Fall, San Francisco, USA, September 5–8, 2011.

TPC Member of the Joint NEWCOM++/COST 2100 Workshop on Wireless Communications (JNCW), Paris, France, March 1–2, 2011.

Associate Editor of the *IEEE Transactions on Antennas and Propagation*.

Chairman of Subworking Group 1.1 on "Antenna System Aspects" in COST Action IC1004.

Richard Lundin:

Co-opted member of Section B of SNRV (Swedish National Committee of URSI).

Daniel Sjöberg:

Co-opted member of Section B of SNRV (Swedish National Committee of URSI).

Niklas Wellander:

Co-opted member of Section B of SNRV (Swedish National Committee of URSI).

7.2 Other official committees

Mats Gustafsson:

Member of the Educational Board I at the Faculty of Engineering, Lund University (Utbildningsnämnd I, UN1).

Anders Karlsson:

Member of the Appointment Board II at the Faculty of Engineering, Lund University (Lärarförslagsnämnd II).

Gerhard Kristensson:

Member of the Board of the Faculty of Engineering (LTH), Lund University.

Member of the Board of the Department of Electrical and Information Technology, Lund University.

Buon Kiong Lau:

Director of Postgraduate Studies for the Department of Electrical and Information Technology, Lund University.

Daniel Sjöberg:

Director of Studies for the Department of Electrical and Information Technology.

Assistant Director of Studies for the Master of Science Educational Program in Engineering Physics at Lund University, Faculty of Engineering (biträdande programledare för civilingenjörsprogrammet i teknisk fysik vid LTH).

Inspector for the PhD Student Chapter of the Student Union at Lund Institute of Technology (Inspektor för doktorandsektionen vid Lunds tekniska högskola).