CODEN:LUTEDX/(TEAT-3025)/1-47/(2014)

Annual Report 2013

Electromagnetic Theory

Electromagnetic Theory
Department of Electrical and Information Technology
Lund University
Sweden

Editor: Gerhard Kristensson

Lund, September 24, 2014

Preface

With this issue, we celebrate the 25th anniversary of the Annual Report. These reports have covered the main research and teaching activities in the Electromagnetic Theory Group over the decades. A comparison between activities during the first staggering years, and the many activities the group now are engaged in, reveals a long scientific journey. There are several reasons for the soaring scientific development of the group — collaboration and scientific diversity have, of course, been important.

Figure 1: Kristin officially nails her thesis on the board in the E-building.

The spring term of 2013 was stressful for everyone in the group. Several sicknesses made the teaching situation hard. With joint efforts we managed, and we are now very happy to find the sick persons back to work again.

Kristin Persson presented her thesis in June, see Figure 1 and figures on pages 12 and 13, where her thesis is reviewed. This event also brought us the pleasure of a visit to Lund by professor Margaret Cheney, who held a Lise Meitner professorship 2000.

The Lise Meitner professorship of Rebecca Seviour ended in June, and we like to thank her for a very fruitful collaboration during her stay with us. We hope the established collaboration will continue in the future.

Andreas Ericsson and Doruk Tayli, see Figure 2, started their graduate studies this year, and we wish them good luck with their studies.

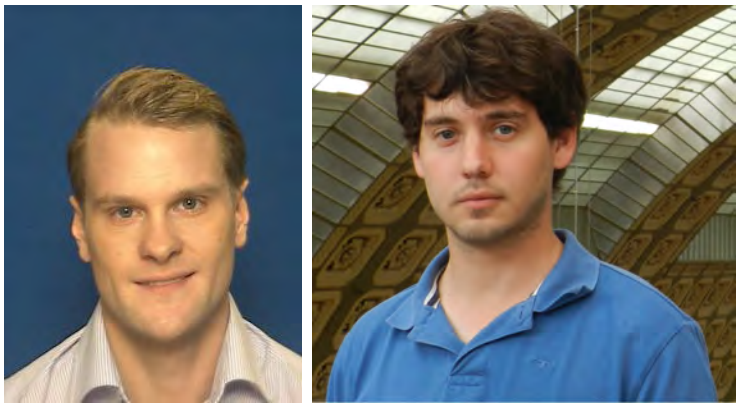

Figure 2: Andreas Ericsson (left) and Doruk Tayli (right).

Mats Gustafsson is appointed IEEE-APS Distinguished Lecturer for 2013–15. This appointment implicates several travel opportunities where he has the possibility to disseminate his research results and to broaden his international network, see Figures 12 and 13 on page 27. As a further example of the success of Mats' research, he was awarded the Best Antenna Theory Paper Award at the European Conference on Antennas and Propagation (EuCAP) in Göteborg. On behalf of the Electromagnetic Theory Group we congratulate him to these well deserved accomplishments.

During recent years, our research efforts have been extended with several new collaboration partners, *e.g.*, TICRA, RUAG AB and ESA. These new space applications on EM theory have a lot of potential and they provide us with new interesting scientific challenges.

Anther important event was the seminar/workshop in June on frequency selective surfaces. Nader Behdad from University of Madison-Wisconsin was the lecturer, see Figure 14 on page 29. The event was financed by the Swedish Defence Materiel Administration (FMV), and it is a continuation of the many seminars held by professor Ben Munk at our department during the 00's.

In Section 1.6 on page 3 a complete list of external funding during 2013 is presented. Our research critically depends on external funding, and we are fortunate to have support from a number of sources including the Swedish Research Council (VR), European Space Agency (ESA), the Swedish National Space Board, VINNOVA, the Swedish Foundation for Strategic Research (SSF), the Swedish Defence Materiel Administration (FMV), and European Spallation Source (ESS). All these generous supports are gratefully acknowledged.

Our research is to a great extent 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 3. We see strong mutual benefits from both parts in this interaction, and we are looking forward to continuing and deepening this collaboration.

Many conferences have been attended by the members of the group during 2013. A list of our efforts at conferences during 2013 is presented in Section 5.5 on page 30. An important event was the URSI International Symposium on Electromagnetic Theory (EMTS 2013) in Hiroshima, Japan, in May. This conference and the work in the international organization URSI engage many of the scientists in the group.

Contents

1 The Electromagnetic Theory Group

1.1 General

The Faculty of Engineering (Lunds Tekniska Högskola, LTH) is Sweden's third largest higher educational institute for the engineering sciences, and 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 Electromagnetic Theory Group is within the Department of Electrical and Information Technology.

The basis for the research and teaching activities of the group is the application of the fundamental macroscopic electromagnetic laws to the generation and propagation of electromagnetic waves in vacuum or materials. Special emphasis is given to the theoretical study of the various devices that can be constructed to amplify and regulate these effects. In our ambition to achieve these goals, analytical, numerical, and experimental techniques are utilized by the group.

The main research activities are concentrated in the area of electromagnetic scattering theory, *e.g.*, antenna and radome applications. Progress in this area is fundamental for the development of devices and technologies that use electromagnetic waves for information exchange. The last few decades have demonstrated an increasing need and demand for technology.

During the last decades, wave propagation phenomena in periodic structures has been a prosperous research field for the Electromagnetic Theory Group. Another important field of research of the group is related to antennas. The use of multiple antenna systems has received growing interest, both in industry and academia, due to the ability to increase the spectral efficiency of wireless communication. In many cases it is desirable to have both high capacity and small physical size. Research in the group has been directed towards establishing physical limitations on information capacity based on antenna size, keyhole effects, and the wave propagation environment.

The two largest research facilities in Sweden, MAX IV and the European Spallation Source (ESS), are located in Lund. This is making Lund to one of Europe's major centers for particle accelerator infrastructures. Since 2010 the group has gradually increased research activities in this field.

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 Electromagnetic Theory Group.

1.2 Personnel

The personnel employed in the group during 2013 is given in the following table:

Name	Degree[a]	Position[b]
Alexander Bondarik	MSc	D
Marius Cismasu	MSc	D
Gabriele Costanza	MSc	D
Andreas Ericsson[c]	TeknD	FA
Mats Gustafsson	TeknD, Doc	P
Anders Karlsson	TeknD, Doc	P
Alireza Kazemzadeh	TeknD	FA
Buon Kiong (Vincent) Lau[d]	TeknD, Doc	UL
Gerhard Kristensson	FD, Doc	P
Richard Lundin	TeknD	UL
Sven Nordebo[e]	TeknD	P
Kristin Persson[f]	TeknL	D
Rebecca Seviour[g]	FD	P
Daniel Sjöberg	TeknD, Doc	P
Doruk Tayli[h]	MSc	D
Iman Vakili	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] Started his employment 2013-07-01.

[d] Employed by the Communications group.

[e] From Linnaeus University. Part time employed during 2013.

[f] Ended her employment 2013-06-15.

[g] Lise Meitner professor. Ended her employment 2013-06-30.

[h] Started his employment 2013-03-01.

1.3 External graduate students (industridoktorander)

This section lists the group's graduate students who are in full-time employment, and at the same time are graduate students in the Electromagnetic Theory Group.

Name	Degree[a]	Company
Michael Andersson	TeknL	Applied Composites AB, Linköping
Magnus Gustafsson	CI	Swedish Defence Research Agency, FOI
David Olsson	CI	Max IV
Renato de Prisco	MSc	European Spallation Source (ESS)

[a] CI Master of Engineering
MSc Master of Science
TeknL Licentiate in Engineering

1.4 Adjunct professors

Four adjunct professors are associated with the Electromagnetic Theory Group:

Name	Degree[a]	Company
Anders Derneryd	TeknD	Ericsson AB
Christer Larsson	FD, Doc	Saab Dynamics AB
Anders Sunesson	TeknD	ESS
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
Andreas Ioannidis	Linnaeus University, Växjö, Sweden

1.6 External funding

The external research support during 2013 is given by:

- The Swedish Research Council (VR). *Principal investigator:* Mats Gustafsson. *Title of the project:* "Optimal antennas integrated in communication and sensor devices".
- The Swedish Research Council (VR). *Principal investigator:* Buon Kiong Lau. *Title of the project:* "Ny antenn system design paradigm för hög prestanda i mobil kommunikation (Novel Antenna System Design Paradigm for High Performance Mobile Communications)".

- European Space Agency (ESA, prime contractor TU Eindhoven, Holland). *Principal investigator:* Daniel Sjöberg. *Title of the project:* "Circular Polarisation Dual-Optics Proof-of-Concept".

- Swedish National Space Board. *Principal investigator:* Daniel Sjöberg. *Title of the project:* "Electromagnetic homogenization of reflector antenna surfaces at vibro-acoustic co-optimization".

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

- VINNOVA. National Aeronautical Research Program (NFFP6). *Principal investigator:* Daniel Sjöberg. *Title of the project:* Signature management for low-flying vehicles.

- Swedish Foundation for Strategic Research (SSF) Strategic Mobility Grant. *Principal investigator:* Mats Gustafsson for collaboration with Ericsson research.

- 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.

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

- Crafoord Foundation. *Principal investigator:* Buon Kiong Lau. Research grant on the design of MIMO antennas for mobile communications.

- Crafoord foundation. *Principal investigator:* Daniel Sjöberg. Funds for near field measurements of millimeter waves.

2 Research Activities

The current research projects of the group are organized into four main 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 engineering

The following subsections give a short general description of the research conducted by the group for each research area above, 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 this research area, the group's focus is on the interaction between electromagnetic fields and material structures. This includes wave propagation in complex materials and structures (inhomogeneous, nonlinear, anisotropic, chiral, frequency selective etc), and mathematical modeling of the physical mechanisms behind the interaction (representations of dispersive effects, homogenization).

The primary question in this activity examines the possibility to reduce the amount of information needed to describe the interaction. For example, wave propagation in strongly inhomogeneous media (many parameters) can be modeled as wave propagation in homogeneous materials (very few parameters) if the wavelength is sufficiently large compared to a characteristic length for the media. This reduction is called homogenization. The properties of the effective homogeneous media must be carefully calculated, usually from a static or quasi-static field perspective. In another class of problems, interaction on an electronic scale can be modeled with voltages and currents in classical circuit models. Here the major challenge lies in constructing accurate models, including the calculation of circuit parameters from static or quasi-static field problems.

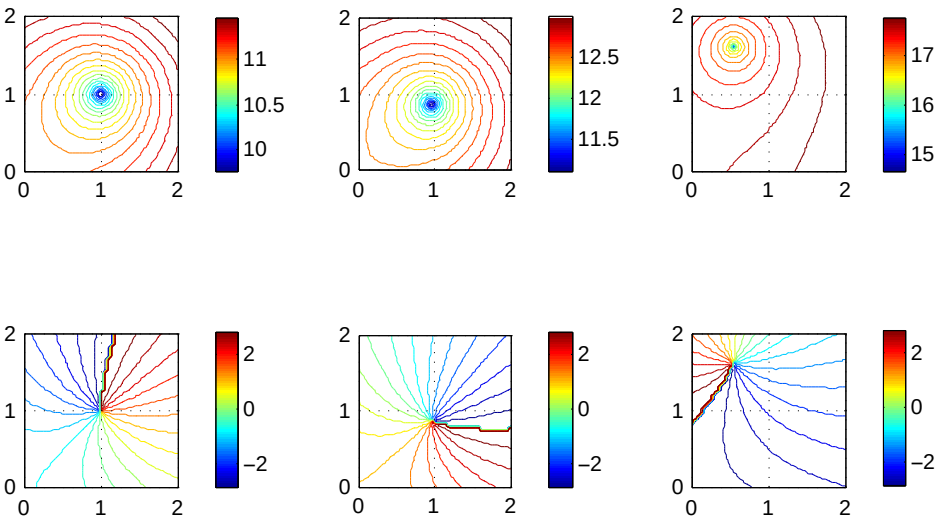

Figure 3: Example of a project under Section 2.1. Illustration of low-frequency asymptotics of propagation constant $\gamma(k)$.

Key journal publications:

S. Nordebo, B. Nilsson, S. Gustafsson, T. Biro, G. Cinar, M. Gustafsson, A. Karlsson, and M. Sjöberg. Low-frequency dispersion characteristics of a multilayered coaxial cable. *Journal of Engineering Mathematics*, **83**(1), 169–184, 2013.

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, that often supply the broader systems perspective.

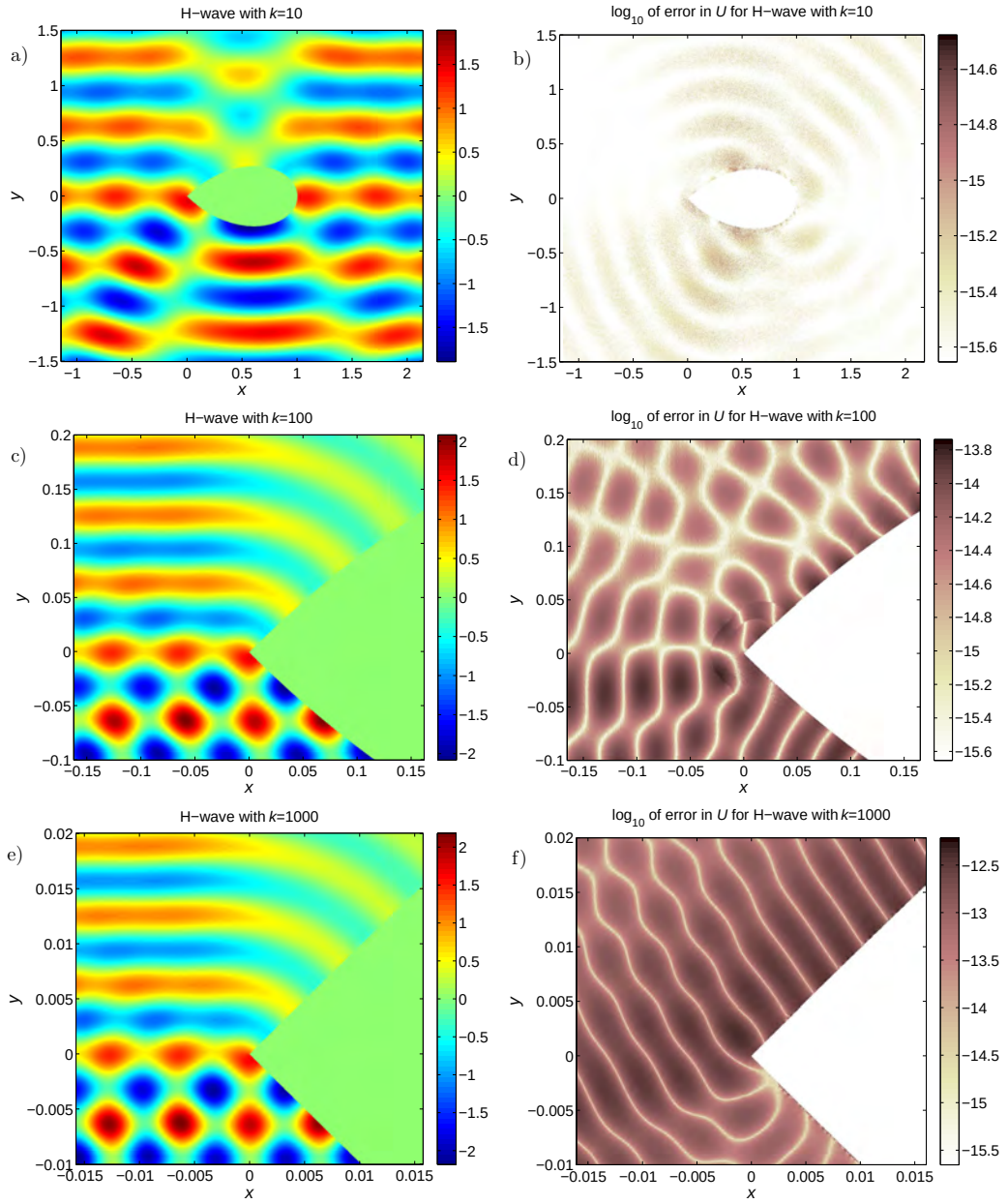

Figure 4: Example of a project under Section 2.2. Fields (left) and errors (right) in log-scale (significant digits) for scattering by a two-dimensional object with a corner.

Key journal publications:

J. Helsing and A. Karlsson. An accurate boundary value problem solver applied to scattering from cylinders with corners. *IEEE Transactions on Antennas and Propagation*, **61**(7), 3693–3700, 2013.

G. Kristensson. Electromagnetic scattering by a bounded obstacle in a parallel plate waveguide. *Journal of Quantitative Spectroscopy and Radiative Transfer*, **123**, 92–102, 2013.

Key technical reports:

Michael Andersson, "Propagators and scattering of electromagnetic waves in planar bianisotropic slabs — an application to absorbers and frequency selective structures,"
LUTEDX/(TEAT-7225)/1-31/(2013).

Niklas Wellander and Gerhard Kristensson, "Estimates of scattered electromagnetic fields,"
LUTEDX/(TEAT-7226)/1-28/(2013).

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 journal publications:

S. Nordebo, M. Gustafsson, B. Nilsson, T. Sjöden, and F. Soldovieri. Fisher information analysis in electrical impedance tomography. *Journal of Geophysics and Engineering*, **10**(6), 064008, 2013.

K. Persson, M. Gustafsson, G. Kristensson, and B. Widenberg. Source reconstruction by far-field data for imaging of defects in frequency selective radomes. *IEEE Antennas and Wireless Propagation Letters*, **12**, 480–483, 2013.

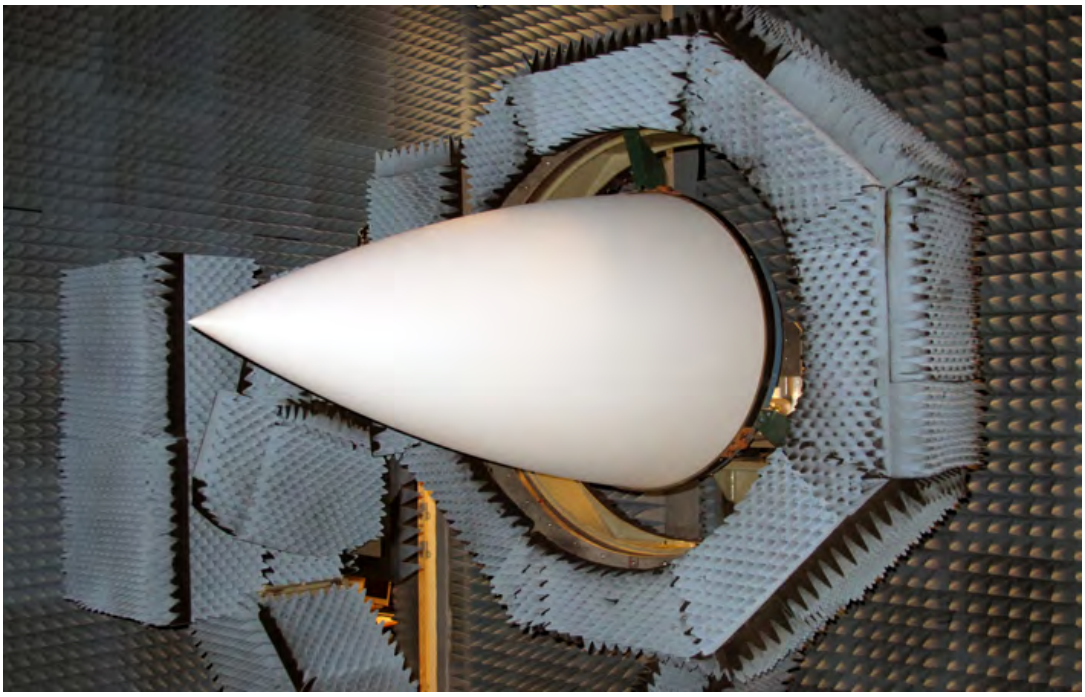

Figure 5: Photo of the radome in the compact test range. This is an example of a project under Section 2.3.

Key technical reports:

Kristin Persson, Mats Gustafsson, Gerhard Kristensson, and Björn Widenberg, "Source reconstruction by far-field data for imaging of defects in frequency selective radomes,"
LUTEDX/(TEAT-7224)/1-14/(2013).

2.4 Antennas and communication

In a wireless system, the antenna is the interface between the electric circuitry 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

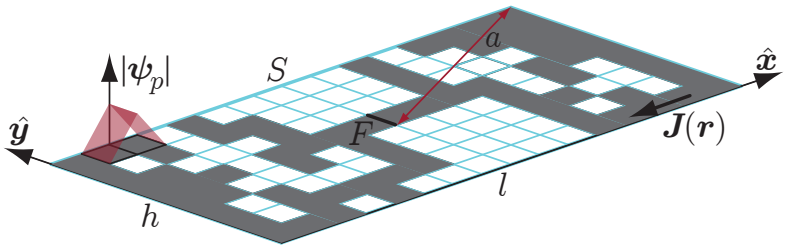

Figure 6: Example of a project under Section 2.4. The uniform rectangular grid defines the discretization of the region. Gray-shaded elements represent metallic patches on which a surface current density $\boldsymbol{J}(\boldsymbol{r})$ can exist.

MIMO systems are investigated. Computational means of simulating the antenna and related structures are also developed.

Collaboration with other research groups at the department is established. Together with the Nanoelectronics group we develop non-dispersive and ultra-wideband antenna system consisting of a leaky lens antenna and an RTD-MOSFET wavelet generator for time domain applications at mm-wave frequencies.

Key journal publications:

J. Fridén and G. Kristensson. Calculation of antenna radiation center using angular momentum. *IEEE Transactions on Antennas and Propagation*, **61**(12), 5923–5930, 2013.

M. Gustafsson and S. Nordebo. Optimal antenna currents for Q, superdirectivity, and radiation patterns using convex optimization. *IEEE Transactions on Antennas and Propagation*, **61**(3), 1109–1118, 2013.

H. Li, X. Lin, B. K. Lau, and S. He. Equivalent circuit based calculation of signal correlation in lossy MIMO antennas. *IEEE Transactions on Antennas and Propagation*, **61**(10), 5214–5222, 2013.

Z. Miers, H. Li, and B. K. Lau. Design of bandwidth enhanced and multiband MIMO antennas using characteristic modes. *IEEE Antennas and Wireless Propagation Letters*, **12**, 1696–1699, 2013.

F. Rusek, D. Persson, B. K. Lau, E. G. Larsson, T. L. Marzetta, O. Edfors, and F. Tufvesson. Scaling up MIMO: opportunities and challenges with very large arrays. *IEEE Signal Processing Magazine*, **30**(1), 40–60, 2013.

I. Vakili, L. Ohlsson, M. Gustafsson, and L.-E. Wernersson. Wideband and Non-Dispersive Wavelet Transmission using Leaky Lens Antenna. *Electronics Letters*, **49**(5), 321–322, 2013.

I. Vasilev, V. Plicanic, R. Tian, and B. K. Lau. Measured adaptive matching performance of a MIMO terminal with user effects. *IEEE Antennas and Wireless Propagation Letters*, **12**, 1720–1723, 2013.

A. D. Yaghjian, M. Gustafsson, and B. L. J. Jonsson. Minimum Q for Lossy and Lossless Electrically Small Dipole Antennas. *Progress In Electromagnetics Research*, **143**, 641–673, 2013.

Key conference publications:

H. Li, X. Lin, B. K. Lau, and S. He. Calculating signal correlation in lossy dipole arrays using scattering parameters and efficiencies. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

H. Li, Z. Miers, and B. K. Lau. Generating multiple characteristic modes below 1 GHz in small terminals for MIMO antenna design. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

Z. Miers, H. Li, and B. K. Lau. Design of multi-antenna feeding for MIMO terminals based on characteristic modes. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

I. Vasilev, E. Foroozanfard, and B. K. Lau. Adaptive impedance matching performance of MIMO terminals with different bandwidth and isolation properties in realistic user scenarios. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

I. Vasilev, V. Plicanic, and B. K. Lau. On user effect compensation of MIMO terminals with adaptive impedance matching. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

Key technical reports:

Marius Cismasu and Mats Gustafsson, "Antenna Bandwidth Optimization with Single Frequency Simulation,"
LUTEDX/(TEAT-7227)/1-18/(2013).

2.5 Accelerator engineering

This activity started in 2010 with the establishment of collaborations with both MAX IV Laboratory and the ESS. Since the fall of 2011 we are running 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, Renato de Prisco. In January 2013 a new project started that involves one graduate student, Gabriele Costanza, and concerns the design of the medium

Figure 7: Kristin Persson (left), the Faculty opponent Margaret Cheney (right) at the dissertation, June 14, 2013.

beta elliptic cavities that are an important part of the ESS accelerator. These cavities are superconducting and are used in the last part of the accelerator.

Together with MAX IV Laboratory a project concerning design of RF-units for acceleration and deflection of the electron beam has been initiated. The PhD student David Olsson is running this project in collaboration with Lars Malmgren at MAX IV and Anders Karlsson.

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3 Dissertations, Published papers and Reports

3.1 Doctoral dissertations

Kristin Persson, "Radome Diagnostics: Utilizing Source Reconstruction Based on Surface Integral Representations," June 14, 2013, see Figures 7 and 8.

Faculty opponent: Professor Margaret Cheney, Department of Mathematics, Colorado State University, USA.

Figure 8: From left: Chairman Daniel Sjöberg, Kristin Persson, Faculty opponent Margaret Cheney, Martin Norgren, Cecilia Cappellin, Samel Arslanagic, Gerhard Kristensson, Lars Pettersson, and Mats Gustafsson, June 14, 2013.

Examining committee:

1) Dr Cecilia Cappellin, TICRA, Copenhagen, Denmark
2) Dr Lars Pettersson, Swedish Defence Research Agency FOI, Linköping, Sweden
3) Professor Martin Norgren, School of Electrical Engineering, the Royal Institute of Technology KTH, Sweden

Alternate member: Samel Arslanagic, Department of Electrical Engineering, Technical University of Denmark DTU, Lyngby, Denmark.
Chairman: Daniel Sjöberg, Electrical and Information Technology, Faculty of Engineering LTH, Lund University, Sweden.

3.1.1 Short presentation of Kristin Persson's thesis

An inverse source reconstruction method with great potential in radome diagnostics is presented and investigated in this dissertation. A radome is a cover that encloses an antenna in order to protect it from environmental influences. Radome diagnostics are acquired in the design process, the delivery control, and in performance verification of repaired and newly developed radomes. A measured near or far field may indicate deviations, *e.g.*, beam deflection, but the origins of the flaws are not uncovered. In this thesis, radome diagnostics is performed by imaging the tangential electromagnetic fields on radome surfaces, disclosing the radome influence on the electromagnetic fields as well as the positions and influences of defects.

The source reconstruction is based on a surface integral representation together

with the extinction theorem. The extinction theorem and its associated surface integral equation ensure that the reconstructed tangential electromagnetic fields have their sources within the radome. The presence of axial symmetry in the measurement set-up enables usage of the fast Fourier transform to reduce the computational complexity. Furthermore, the problem is solved by an in-house body of revolution method of moments (MoM) code utilizing a singular value decomposition (SVD) for regularization. The reconstruction is performed on a fictitious surface in free space, located precisely outside the physical surface of the radome, i.e., no a priori information of the material of the radome is requested. Moreover, both synthetic and measured data are used to verify the method.

The dissertation is composed of five papers. In the first three papers, the measurement set-up is a reflector antenna covered by a monolithic radome, and the near field is measured on a cylindrical surface. The height of the radome corresponds to 29–43 wavelengths in the frequency interval 8.0–12.0 GHz. The amplitude and phase of the tangential electromagnetic fields are reconstructed on the radome surface and the influence of the radome is investigated. Moreover, the alteration of the phase due to the transmission of the radome, the insertion phase delay (IPD), is imaged. Defects in the form of square copper patches, with an edge length corresponding to 1.6–2.4 wavelengths in the considered frequency interval, are attached to the radome wall. These might serve as a model for *e.g.*, a lightning conductor or a Pitot tube. The attached patches alter the near field, and by applying source reconstruction, the disturbances of the patches are focused and detectable.

In the fourth paper, the field is measured on a spherical sector in the far-field region at 10.0 GHz. Two set-ups with dielectric defects attached to the radome surface, are investigated. The aim is to investigate if variations in the electrical thickness of the radome wall can be detected. It is concluded that it is possible to discover dielectric patches of various edge sizes (0.5–2.0 wavelengths), and with the smallest thickness corresponding to a phase shift of a couple of degrees.

In the last paper, a frequency selective (FSS) radome corresponding to a height of 51 wavelengths at the frequency 9.35 GHz is investigated. The electrical performance of an FSS radome depends on the periodic structure of the elements in the radome frame. The periodic structure of the investigated radome is disrupted by horizontal defects (vertical displacements of elements) and vertical defects (a column of missing elements). The far-field data is measured on a spherical sector, and the far-field data reveals that the radome changes the radiation properties. The tangential electromagnetic fields on the radome surface are reconstructed for several antenna illuminations to image the cause of these alterations. Furthermore, it is shown that the different components of the electromagnetic fields are affected differently by the defects, implying that both co- and cross-components of the electric and magnetic fields need to be considered. Moreover, the Poynting's vector is employed to visualize how the defects block the field from the antenna.

3.2 Licentiate dissertations

No licentiate dissertations were presented this year.

3.3 Journal publications

J1. J. Fridén and G. Kristensson. Calculation of antenna radiation center using angular momentum. *IEEE Transactions on Antennas and Propagation*, **61**(12), 5923–5930, 2013.

J2. J. Gong, S. Zhou, B. K. Lau, and Z. Niu. On precoding for overlapped clustering in a measured urban macrocellular environment. *Science China Information Sciences (Special Issue on Future Wireless and Mobile Communication)*, **56**(2), 022301–38, 2013.

J3. M. Gustafsson and S. Nordebo. Optimal antenna currents for Q, superdirectivity, and radiation patterns using convex optimization. *IEEE Transactions on Antennas and Propagation*, **61**(3), 1109–1118, 2013.

J4. J. Helsing and A. Karlsson. An accurate boundary value problem solver applied to scattering from cylinders with corners. *IEEE Transactions on Antennas and Propagation*, **61**(7), 3693–3700, 2013.

J5. X. Hou, C. Yang, and B. K. Lau. On channel quantization for multi-cell cooperative systems with limited feedback. *Science China Information Sciences (Special Issue on Future Wireless and Mobile Communication)*, **56**(2), 1–16, 2013.

J6. N. Jamaly, A. Derneryd, and Y. Rahmat-Samii. Spatial Diversity Performance of Multiport Antennas in the Presence of a Butler Network. *IEEE Transactions on Antennas and Propagation*, **61**(11), 5697–5705, 2013.

J7. A. Karlsson. On the efficiency and gain of antennas. *Progress in Electromagnetic Research*, **136**, 479–494, 2013.

J8. A. Karlsson, Y. Tan, and P.-E. Bengtsson. Absorption and scattering of light from ensembles of randomly oriented aggregates. *Journal of the Optical Society of America A*, **30**(3), 316–324, 2013.

J9. G. Kristensson. Electromagnetic scattering by a bounded obstacle in a parallel plate waveguide. *Journal of Quantitative Spectroscopy and Radiative Transfer*, **123**, 92–102, 2013.

J10. H. Li, X. Lin, B. K. Lau, and S. He. Equivalent circuit based calculation of signal correlation in lossy MIMO antennas. *IEEE Transactions on Antennas and Propagation*, **61**(10), 5214–5222, 2013.

J11. Z. Miers, H. Li, and B. K. Lau. Design of bandwidth enhanced and multiband MIMO antennas using characteristic modes. *IEEE Antennas and Wireless Propagation Letters*, **12**, 1696–1699, 2013.

J12. S. Nordebo, M. Gustafsson, B. Nilsson, T. Sjöden, and F. Soldovieri. Fisher information analysis in electrical impedance tomography. *Journal of Geophysics and Engineering*, **10**(6), 064008, 2013.

J13. S. Nordebo, B. Nilsson, S. Gustafsson, T. Biro, G. Cinar, M. Gustafsson, A. Karlsson, and M. Sjöberg. Low-frequency dispersion characteristics of a multilayered coaxial cable. *Journal of Engineering Mathematics*, **83**(1), 169–184, 2013.

J14. L. Ohlsson, T. Bryllert, C. Gustafson, D. Sjöberg, M. Egard, M. Ärlelid, and L.-E. Wernersson. Slot-Coupled Millimeter-Wave Dielectric Resonator Antenna for High-Efficiency Monolithic Integration. *IEEE Transactions on Antennas and Propagation*, **61**(4), 1599–1607, 2013.

J15. K. Persson, M. Gustafsson, G. Kristensson, and B. Widenberg. Source reconstruction by far-field data for imaging of defects in frequency selective radomes. *IEEE Antennas and Wireless Propagation Letters*, **12**, 480–483, 2013.

J16. F. Rusek, D. Persson, B. K. Lau, E. G. Larsson, T. L. Marzetta, O. Edfors, and F. Tufvesson. Scaling up MIMO: opportunities and challenges with very large arrays. *IEEE Signal Processing Magazine*, **30**(1), 40–60, 2013.

J17. I. Vakili, L. Ohlsson, M. Gustafsson, and L.-E. Wernersson. Wideband and Non-Dispersive Wavelet Transmission using Leaky Lens Antenna. *Electronics Letters*, **49**(5), 321–322, 2013.

J18. I. Vasilev, V. Plicanic, R. Tian, and B. K. Lau. Measured adaptive matching performance of a MIMO terminal with user effects. *IEEE Antennas and Wireless Propagation Letters*, **12**, 1720–1723, 2013.

J19. A. D. Yaghjian, M. Gustafsson, and B. L. J. Jonsson. Minimum Q for Lossy and Lossless Electrically Small Dipole Antennas. *Progress In Electromagnetics Research*, **143**, 641–673, 2013.

3.4 Books

B1. A. Karlsson and G. Kristensson. *Microwave Theory.* Tryckeriet i E-huset, Lund University, 2013.

3.5 Conference publications

C1. M. Cismasu and M. Gustafsson. Antenna Bandwidth Optimization by Genetic Algorithms with Single Frequency Simulation. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C2. M. Cismasu and M. Gustafsson. Illustration of mobile terminal antenna optimization by genetic algorithms with single frequency simulation. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C3. R. de Prisco, M. Comunian, F. Grespan, A. Piscent, and A. Karlsson. ESS DTL RF Modelization: Field tuning and stabilization. IPAC 2013, 2013-05-12, 2013.

C4. J. Fridén and G. Kristensson. Calculation of antenna radiation center using angular momentum. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, 2013.

C5. M. Gustafsson. An overview of physical bounds on small antennas. Progress in Electromagnetics Research Symposium (PIERS), 2013-08-14, 2013.

C6. M. Gustafsson. An overview of sum rules and physical limitations for passive metamaterial structures. META13, the 4th International Conference on Metamaterials, Photonic Crystals and Plasmonics, 2013-03-18/2013-03-22, 2013.

C7. M. Gustafsson. Convex optimization for analysis of small antennas. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C8. M. Gustafsson. Efficiency and Q for small antennas using Pareto optimality. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

C9. M. Gustafsson. Optimal currents on small antennas using convex optimization. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C10. M. Gustafsson. Small antenna analysis using convex optimization. AES 2013, the 2nd Advanced Electromagnetics Symposium, 2013-03-20, 2013.

C11. M. Gustafsson. Small antenna analysis using convex optimization. Progress in Electromagnetics Research Symposium (PIERS), 2013-08-13, 2013.

C12. M. Gustafsson, I. Vakili, and D. Sjöberg. All spectrum identities for periodic metamaterials. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C13. J. Helsing and A. Karlsson. An accurate near-field solver for scattering from cylinders with corners. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C14. B. Jonsson and M. Gustafsson. Stored energies for electric and magnetic currents with applications to Q for small antennas. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C15. G. Kristensson. EM scattering by a bounded obstacle in a parallel plate waveguide. Electromagnetic & Light scattering, 2013-06-17/2013-06-21, 2013.

C16. G. Kristensson. Scattering by inhomogeneities in parallel plate waveguides. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C17. H. Li, X. Lin, B. K. Lau, and S. He. Calculating signal correlation in lossy dipole arrays using scattering parameters and efficiencies. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C18. H. Li, Z. Miers, and B. K. Lau. Generating multiple characteristic modes below 1 GHz in small terminals for MIMO antenna design. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

C19. Z. Miers, H. Li, and B. K. Lau. Design of multi-antenna feeding for MIMO terminals based on characteristic modes. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

C20. K. Persson, M. Gustafsson, G. Kristensson, and B. Widenberg. Source reconstruction for radome diagnostics. Progress in Electromagnetics Research Symposium (PIERS), 2013-08-13, 2013.

C21. D. Sjöberg. Local Problems for Homogenization of Periodic Thin Films. International Conference on Electromagnetics in Advanced Applications (ICEAA), 2013-09-09, IEEE, 2013.

C22. D. Sjöberg. Scattering for singly curved functional surfaces and corresponding planar designs. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C23. D. Sjöberg. Using web quizzes to assess concept understanding and pacing the students. Progress In Electromagnetics Research Symposium, 2013-08-12, 2013.

C24. D. Sjöberg, M. Gustafsson, and R. Seviour. A Sum Rule and Physical Bound for Electromagnetic Band Gap Structures. International Conference on Electromagnetics in Advanced Applications (ICEAA), 2013-09-09, IEEE, 2013.

C25. D. Sjöberg and C. Larsson. Material Characterization in Partially Filled Waveguides Using Inverse Scattering and Multiple Sample Orientations. URSI International Symposium on Electromagnetic Theory, Hiroshima, Japan, 2013-05-20/2013-05-24, IEEE, 2013.

C26. I. Vakili, L. Ohlsson, M. Gustafsson, and L.-E. Wernersson. Pulse transmission using leaky lens antenna and RTD-MOSFET wavelet generator. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C27. I. Vasilev, E. Foroozanfard, and B. K. Lau. Adaptive impedance matching performance of MIMO terminals with different bandwidth and isolation properties in realistic user scenarios. The 7th European Conference on Antennas and Propagation (EuCAP), 2013-04-08/2013-04-12, IEEE, 2013.

C28. I. Vasilev, V. Plicanic, and B. K. Lau. On user effect compensation of MIMO terminals with adaptive impedance matching. IEEE International Symposium on Antennas and Propagation, 2013-07-07/2013-07-13, 2013.

3.6 Thesis publications

T1. K. Persson. *Radome Diagnostics: utilizing Source Reconstruction based on Surface Integral Representations.* PhD thesis, 2013.

3.7 Diploma works

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

D1. Andreas Ericsson, "Self-Supported Hat Feed Reflector Antenna for SATCOM Applications."
Advisor: Cecilia Cappellin (Ticra) and Mats Gustafsson
Examiner: Daniel Sjöberg

D2. Joel Andersson, "Electron gun investigations at MAX IV laboratory."
Advisor: Francesca Curbis (Lund University)
Examiner: Anders Karlsson

D3. Viktor Liljegren, "Evaluation of Circular Polarization Selective Surfaces for Space Applications."
Advisor: Daniel Sjöberg
Examiner: Mats Gustafsson

D4. Jin Liu, "UWB leaky lens antenna design and simulation for waveguide measurements."
Advisors: Iman Vakili and Mats Gustafsson
Examiner: Daniel Sjöberg

D5. Madeleine Schilliger Kildal, "Detection of traumatic epidural and subdural haematomas in brain phantoms using microwave technology."
Advisor: Stefan Candefjord (Chalmers)
Examiner: Mats Gustafsson

D6. Ellinor Persson and Ahmed Al-Muqayad, "A study of the field distribution on finite array endfire antennas."
Advisor: Daniel Sjöberg
Examiner: Mats Gustafsson

D7. Teresia Olsson, "High-chromaticity Optics for the MAX IV 3 GeV Storage Ring."
Advisor: Simon Leemann (Maxlab)
Examiner: Anders Karlsson

D8. Tobias Lindqvist "Field parametrization by trigonometric expansion combined with particle tracking in superconducting cavities."

Advisor: Emanuele Laface (ESS)
Examiner: Anders Karlsson

3.8 Technical reports

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

TR1. Kristin Persson, Mats Gustafsson, Gerhard Kristensson, and Björn Widenberg, "Source reconstruction by far-field data for imaging of defects in frequency selective radomes,"
LUTEDX/(TEAT-7224)/1-14/(2013).
Abstract: In this paper, an inverse source reconstruction method with great potential in radome diagnostics is presented. Defects, *e.g.*, seams in large radomes, and lattice dislocations in frequency selective surface (FSS) radomes, are inevitable, and their electrical effects demand analysis. Here, defects in a frequency selective radome are analyzed with a method based on an integral formulation. Several far-field measurement series, illuminating different parts of the radome wall at 9.35 GHz, are employed to determine the equivalent surface currents and image the disturbances on the radome surface.

TR2. Michael Andersson, "Propagators and scattering of electromagnetic waves in planar bianisotropic slabs — an application to absorbers and frequency selective structures,"
LUTEDX/(TEAT-7225)/1-31/(2013).
Abstract: The concept of propagators for solving scattering problems in planar geometries has been generalized to accommodate thin homogeneous, in general anisotropic, resistive sheets embedded in supporting slabs, by the usage of a well known approximate impedance boundary condition. The slabs can be arbitrary linear materials *i.e.*, bianisotropic materials, and applications of the method to the analysis of single and multilayer absorbers *i.e.*, Salisbury and Jaumann absorbers are given. The generalization of the propagator method also handles the problem with an arbitrary number of metallic sheets consisting of resistive patch elements embedded in supporting linear, bianisotropic slabs. The solution of both the case of finite number of patch elements and the case where the elements are periodically arranged, is shown by the use of the Galerkin method. Numerical examples, where comparison to data presented in the literature as well as measured data, are shown in the paper.

TR3. Niklas Wellander and Gerhard Kristensson, "Estimates of scattered electromagnetic fields,"
LUTEDX/(TEAT-7226)/1-28/(2013).
Abstract: We present some general estimates of the scattered electromagnetic fields for a general bounded scattering domain Ω in the anisotropic materials setting.

In particular, it is shown that the $||\cdot||_{L^2(\Omega_s;\mathbb{C}^3)}$ -norm and sup-norm of the scattered field in an arbitrary finite exterior domain Ω_s are bounded by the $H(\text{curl},\Omega)$ norm of the incident field. Moreover, several estimates of the traces of the scattered field on the boundary and a circumscribing sphere are presented.

TR4. Marius Cismasu and Mats Gustafsson, "Antenna Bandwidth Optimization with Single Frequency Simulation,"
LUTEDX/(TEAT-7227)/1-18/(2013).
Abstract: A method to compute antenna Q using an electromagnetic simulation at a single frequency is described. This method can easily be integrated into global optimization algorithms. In this way the optimization time of some antenna parameters, *e.g.*, bandwidth, may be significantly reduced. The method is validated by direct comparison with the physical bound of the analyzed structure. Numerical examples for rectangular antennas and antennas with a rectangular ground plane illustrate the integration of the method into a genetic algorithm. The results predicted by optimization agree very well with those obtained using a commercial electromagnetic solver. These results suggest that the method can be used to yield antennas with Q factors within 20 % of their corresponding physical bound.

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4 Guests and Seminars

4.1 Visitors at the group of Electromagnetic Theory

Nader Behdad, University of Madison-Wisconsin, USA, June 9–12, 2013.

Anders Bernland, EDS, Göteborg, Sweden, March 26, 2013.

Jonas Fridén, Ericsson AB, Lindholmen, Göteborg, Sweden, numerous visits during 2013.

Magnus Herberthson, Swedish Defence Research Agency, FOI, Linköping, Sweden, November 28, 2013.

Koichi Ito, Chiba University, Chiba, Japan, April 5, 2013.

Kazuya Kobayashi, Chuo University, Tokyo, Japan, August 16, 2013, see Figure 9.

Carina Marcus, Saab Aerosystems AB, Linköping, Sweden, March 26, 2013.

Torleif Martin, Saab Aerosystems AB, Linköping, Sweden, January 15, November 26, 2013.

Figure 9: Kazuya Kobayashi, Chuo University, Tokyo, Japan, visits Lund in August 2013.

Graeme Milton, Department of Mathematics, University of Utah, USA, April 4–5, 2013.

Philip Nilsson, Engineering Geology, LTH, October 30, 2013.

Sven Nordebo, Department of Physics and Electrical Engineering, Linnaeus University, Växjö, Sweden, numerous visits during 2013.

Glenn Sjöberg, EDS, Göteborg, Sweden, March 26, 2013.

Bo Strand, Efield, Kista, Sweden, March 26, 2013.

Maria Tengner, Saab Dynamics AB, Sweden, November 6, 2013.

Zhinong Ying, Sony Mobile Communications AB, Sweden, numerous visits during 2013.

4.2 Seminars

Kristin Persson, " Radome diagnostics using equivalent surface currents reconstructed from compact range measurements," January 25, 2013.

Mats Gustafsson, "Stored electromagnetic energies," February 1, 2013.

Magnus Gustafsson, "A New Methodology for Measuring the Bistatic Ground Scattering Coefficient. Comparisons with the AIEM at Large Bistatic Angles," February 8, 2013.

Nathan Woollett, "Hidden Sector Photon Searches," February 22, 2013.

Daniel Sjöberg, "A physical bound on band gaps in periodic structures," March 1, 2013.

Alexander Bondarik, "Stacked microstrip antenna with gridded patch for 60 GHz band," March 8, 2013.

David Olsson, "Phase modulation in the MAX-lab accelerator," March 15, 2013.

Gabriele Costanza, "Advances in the design of the Medium Beta Elliptical Cavity for the ESS," March 22, 2013.

Marius Cismasu, "Antenna Bandwidth Optimization by Genetic Algorithms with Single Frequency Simulation," April 3, 2013.

Iman Vakili, "Pulse transmission using lens antenna and MOSFET wavelet generator," April 3, 2013.

Graeme Milton, "Non-linear metamaterials from rods and hinges," April 5, 2013.

Gerhard Kristensson, "Electromagnetic scattering by a bounded obstacle in a parallel plate waveguide," April 19, 2013.

Doruk Tayli, "Linking CST and Matlab: A short tutorial," April 3, 2013.

Koichi Ito, "Antennas for Body-Centric Wireless Communications," April 5, 2013.

Kazuya Kobayashi, "Radar Cross Section Analysis of Two Canonical, Parallel-Plate Waveguide Cavities with Material Loading," August 16, 2013.

Andreas Ericsson, "Electromagnetic Homogenization of Reflector Antenna Surfaces," August 30, 2013.

Anders Karlsson, "Helmholtz resonances in axially symmetric domains," September 6, 2013.

Daniel Sjöberg, "Circular polarization selective structures," September 20, 2013.

Andreas Ioannidis, "On the mathematical solution of the cavity EM propagation problem," September 27, 2013.

Gerhard Kristensson, "Introduction to TikZ," October 11, 2013.

Daniel Sjöberg, "A Sum Rule and Physical Bound for Electromagnetic Band Gap Structures," October 18, 2013.

Carl Gustafson, "Radar Measurements using the Phase Shift Migration Method," October 25, 2013.

Gabriele Costanza, "An introduction to Linear models," November 1, 2013.

Maria Tengner, "A story of quantum information — photons, entanglement and keeping secrets," November 6, 2013.

Alexander Bondarik, "Gridded Parasitic Patch Microstrip Antenna," November 8, 2013.

Mats Gustafsson, "Mathematical modeling of causal signals and passive systems," November 21, 2013.

Torleif Martin, "Electromagnetic theory — an industrial perspective," November 26, 2013.

Magnus Herberthson, "A rigorous high frequency limit investigation of the MIE scattering from a PEC sphere," November 28, 2013.

Daniel Sjöberg, "Electrical properties of the plastic used in 3D-printers," December 13, 2013.

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5 Visits and Lectures by the Staff

5.1 Visits to other institutes and departments

Mats Gustafsson:

Electromagnetic Engineering (ETK) at Royal Institute of Technology (KTH), Stockholm, Sweden, January 28, 2013.

Ericsson research, Göteborg, Sweden, numerous visits during 2013.

Signals and Systems, Chalmers, Göteborg, Sweden, March 13, 2013.

Orange Labs, Nice, France, September 19–20, 2013, see Figure 10.

Gerhard Kristensson:

URSI EMTS, TAP B meeting, University, Italy, January 11-12, 2013.

FoT-meeting, FMV, Stockholm, Sweden, February 12, 2013.

INRA evaluation meeting, Paris, France, March 27–29, 2013.

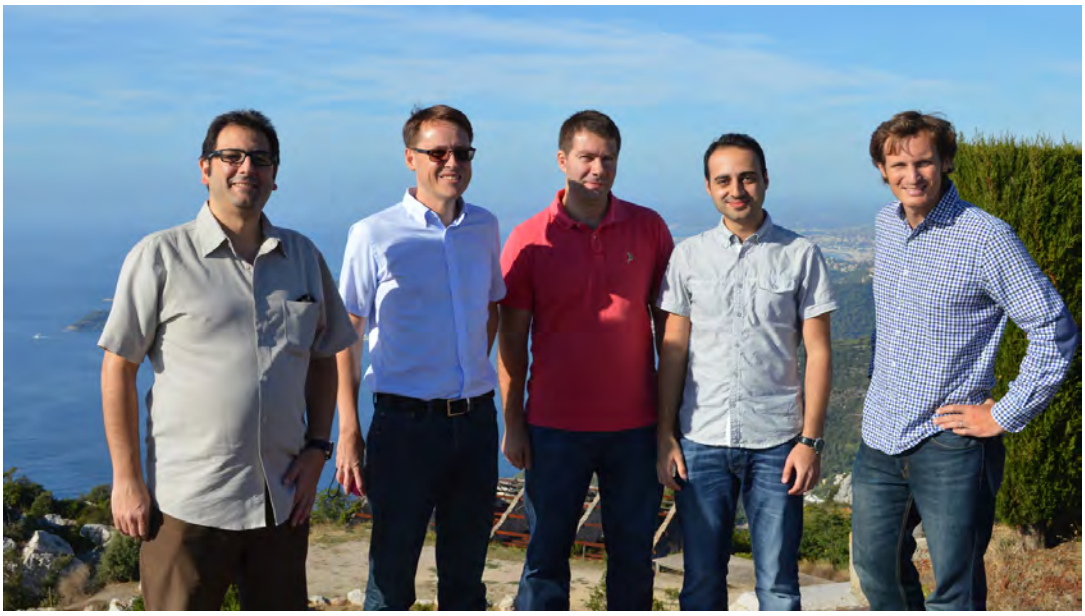

Figure 10: From left: Cyril Luxey, Mats Gustafsson, Alexander Bondarik, Iman Vakili, and Ferrero Fabien at Orange Labs, Nice in September 2013.

SNRV (Swedish National Committee of URSI), annual meeting, Riga and Ventspils, Latvia, April 21–22, 2013.

Finnish URSI Radio Science Days 2013, Espoo, Finland, April 23–24, 2013, see Figure 11.

SNRV (Swedish National Committee of URSI), autumn meeting, The Royal Swedish Academy of Sciences, Stockholm, Sweden, November 12, 2013.

Presentation of the Swedish National Committee of Radio Science (SNRV) at the Royal Swedish Academy of Sciences, Stockholm, Sweden, November 13, 2013.

Daniel Sjöberg:

FMV, Stockholm, February 14, 2013.

NRFP2 seminar, RUAG Space AB, Göteborg, Sweden,March 21, 2013. *Title of talk:* "Elektromagnetisk homogenisering av reflektorantennytor vid vibroakustisk samoptimering".

NFFP5 meeting, Efield AB, Stockholm, Sweden, June 18, 2013.

NFFP6 meeting, SBD, Linköping, Sweden, October 30, 2013.

NFFP6 meeting, SBD, Linköping, Sweden, November 5, 2013.

NRFP2 meeting, RUAG Space AB, Sweden, November 20, 2013.

Figure 11: The Swedish National Committee of URSI visits the Finnish URSI Radio Science Days 2013. From left: Henrik Wallén (Secretary, URSI Finland), Ari Sihvola (Chair, URSI Finland), Gerhard Kristensson (Chair, URSI Sweden), and Carl-Henrik Walde (Secretary, URSI Sweden). See also Radio Science Bulletin, No 345 June 2013, for more details.

Hultsfreds Gymnasium, Hultsfred, Sweden, November 15, 2013.

NFFP6 meeting, SBD, Linköping, Sweden, December 5, 2013.

EMB (National Computational Electromagnetics meeting), FOI, Linköping, Sweden, December 6, 2013.

5.2 Guest Lectures by the department's staff

Mats Gustafsson:

Ericsson research in Göteborg, Sweden. *Title of the talk:* "Antennas, 60GHz, and diagnostics," May 2, 2013.

Ericsson research in Kista. *Title of the talk:* "Antennas, SAR, and optimization," October 1, 2013.

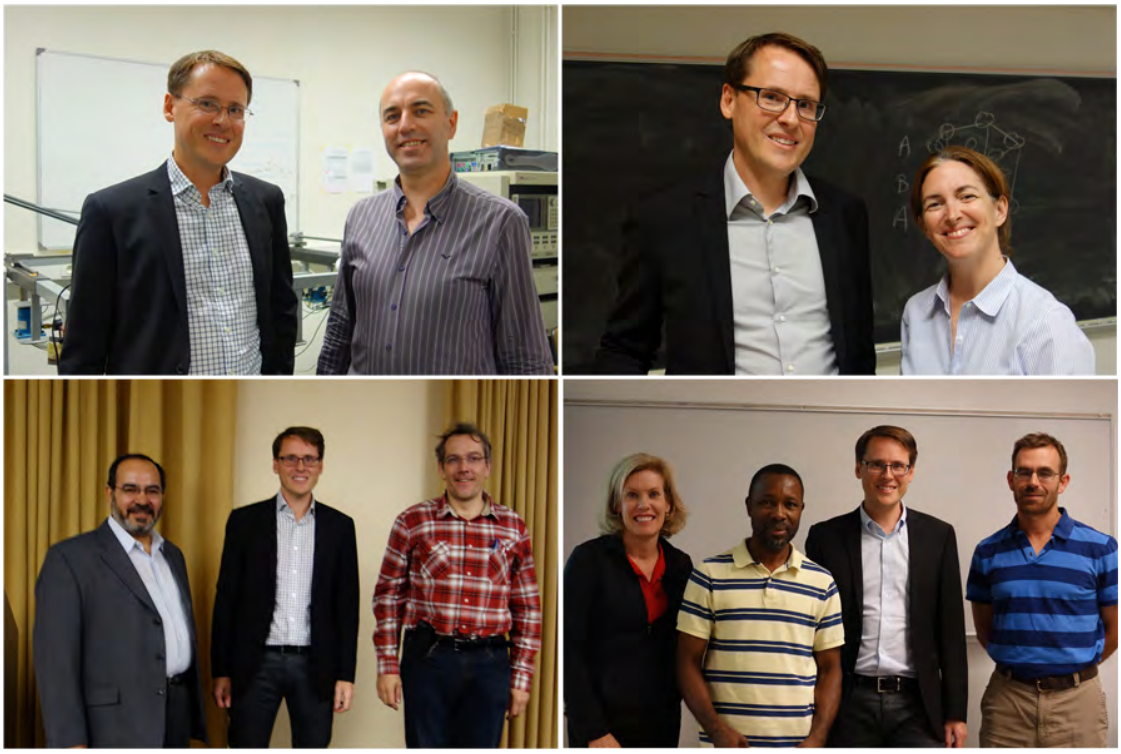

Figure 12: Mats Gustafsson at KU Leuven, Belgium (upper left), University of Illinois at Urbana-Champaign, USA (upper right), Concordia, Montreal, Canada (lower left), and at University of Arizona, Tucson, USA (lower right).

Figure 13: Mats Gustafsson at the University of Illinois at Chicago (left) and at École Polytechnique de Montréal, Canada (right).

IEEE APS Distinguished Lecturer Program.
Title of the talk: "Convex Optimization for Optimal Design and Analysis of Small Antennas," at, see Figures 12 and 13

- KU Leuven, Belgium, September 12, 2013.
- University of Illinois at Urbana-Champaign, USA, October 8, 2013.
- University of Illinois at Chicago, USA, October 11, 2013.
- Concordia, Montreal, Canada, October 15, 2013.
- University of Arizona, Tucson, USA, October 22, 2013.
- Bhubaneswar, India, December 19, 2013.

IEEE APS Distinguished Lecturer Program.
Title of the talk: "Sum Rules and Physical Bounds in Electromagnetics," at École Polytechnique de Montréal, Canada, October 17, 2013.

5.3 Awards

Hui Li, Buon Kiong Lau, Zhinong Ying, and Sailing He

CST University Publication Award 2013 for the paper: , "Decoupling of Multiple Antennas in Terminals With Chassis Excitation Using Polarization Diversity, Angle Diversity and Current Control" *IEEE Transactions on Antennas and Propagation*, **60**(12), 5947–5957, December, 2012.

Mats Gustafsson:

Best Antenna Theory Paper Award at the European Conference on Antennas and Propagation (EuCAP), Göteborg, Sweden, 2013.

5.4 Organization of Courses, Conferences, and Workshops

1. Seminar/Workshop on LO/FSS by Professor Nader Behdad, University of Madison-Wisconsin, USA, held at the Department of Electrical and Information Technology, Lund, Sweden, June 10–11, 2013, see also Figure 14.
   Program of the Seminar:
   a) General introduction and overview of research
   b) Biomimetic, electrically small antennas
   c) Low profile, ultra-wideband antennas
   d) Miniaturized-element frequency selective surfaces (MEFSSs) and their applications
      - Fundamentals of MEFSSs

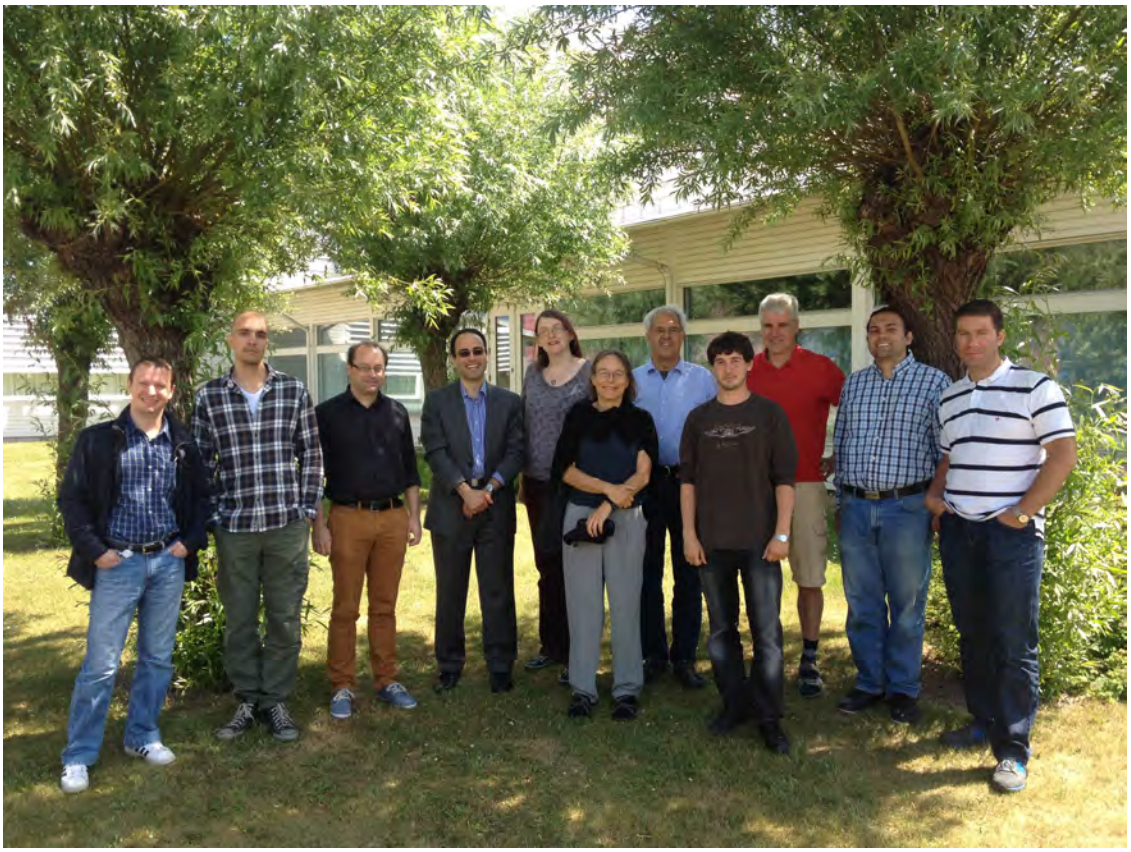

Figure 14: Professor Nader Behdad, University of Madison-Wisconsin, USA, visits Lund, June 10–11, 2013. From left: Marius Cismasu, Gabriele Contanza, Daniel Sjöberg, Nader Behdad, Rebecca Saviour, Margaret Cheney, Gerhard Kristensson, Doruk Tayli, Anders Karlsson, Alireza Kazemzadeh, and Alexander Bondarik.

- Harmonic suppressed MEFSSs and their applications in designing low-observable, broadband antennas
- Frequency selective surfaces for high-power microwave applications

2. COST IC1102 (VISTA) and COST IC1004 Joint Workshop "Terminal Antenna Systems for 4G and Beyond," Ghent, Belgium, September 25, 2013. **Co-chairs:** Marta Martinez Vázquez and Buon Kiong Lau. There were 13 technical presentations and around 120 registered participants.

3. Short Course on "On Performance Metrics for MIMO Antennas" at the European Conference on Antennas and Propagation (EuCAP 2013), Göteborg, Sweden, April 7, 2013. **Presenters:** Buon Kiong Lau and Hui Li.

4. Member of the Subcommittee 1 (CEM, EMC, Scattering and Electromagnetic Theory) at the Progress In Electromagnetics Research Symposium (PIERS 2013), Stockholm, Sweden, August 12–15, 2013. **Member:** Gerhard Kristensson

5.5 Participation in conferences and workshops

Mats Gustafsson:

Participated with an invited oral paper at the 4th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META13), Sharjah, UAE. *Title of the Paper:* " An overview of sum rules and physical limitations for passive metamaterial structures," March 18–22, 2013.

Participated with an oral paper at the 2nd Advanced Electromagnetics Symposium (AES2013), Sharjah, UAE. *Title of the Paper:* "Small antenna analysis using convex optimization," March 18–22, 2013.

Participated with an oral paper at the 7th European Conference on antennas and Propagation (EuCAP 2013), Göteborg, Sweden. *Title of the Paper:* "Convex optimization for analysis of small antennas," April 08–12, 2013.

Chairman at the 7th European Conference on antennas and Propagation (EuCAP 2013), Göteborg, Sweden. *Title of the Session:* "Adaptive and reconfigurable antennas," April 08–12, 2013.

Participated with an invited oral paper and one oral paper at the URSI International Symposium on Electromagnetic Theory (EMTS 2013), Hiroshima, Japan. *Title of the Paper:* "All spectrum identities for periodic metamaterials Optimal currents on small antennas using convex optimization," May 20–24, 2013.

Chairman at the URSI International Symposium on Electromagnetic Theory (EMTS 2013), Hiroshima, Japan. *Title of the Session:* "Electrically Small Antennas," May 20–24, 2013.

Participated with an invited oral paper at the 2013 IEEE International Symposium on Antennas and Propagation, Orlando, Florida, USA. *Title of the Paper:* "Efficiency and Q for small antennas using Pareto optimality," July 07–13, 2013.

Chairman at the 2013 IEEE International Symposium on Antennas and Propagation, Orlando, Florida, USA. *Title of the Session:* "Small Antennas: Theory, Designs, and Realizations," July 07–13, 2013.

Organized one focus session together with Zhinong Ying (Sony Mobile Communication AB) at Progress in Electromagnetics Research Symposium (PIERS), Stockholm, Sweden. *Title of the Focus Session:* "Challenges for Small Antennas," August 12–15, 2013.

Organized one special session together with Sven Nordebo at Progress in Electromagnetics Research Symposium (PIERS), Stockholm, Sweden. *Title of the Special Session:* "Inverse Source Problems for Localization and Diagnostics," August 12–15, 2013.

Participated with two oral papers and one invited oral paper at the Progress in Electromagnetics Research Symposium (PIERS), Stockholm, Sweden. *Title of the Paper:* "An overview of physical bounds on small antennas Source reconstruction for radome diagnostics Small antenna analysis using convex optimization," August 12–15, 2013.

Participated with an IEEE Distinguished lecture at the 4$^{\text{th}}$ Applied Electromagnetics Conference, AEMC 2013, KIIT University, Bhubaneswar, India. December 18–20 2013.

Gerhard Kristensson:

Participated in the Commission B Technical Advisory Board (B-TAB) of URSI Commission B, Pisa, Italy. January 11–12, 2013.

Participated with an oral paper at the URSI International Symposium on Electromagnetic Theory (EMTS 2013), Hiroshima, Japan. *Title of the paper:* "Scattering by inhomogeneities in parallel plate waveguides," May 20–24, 2013.

Chairman at the URSI International Symposium on Electromagnetic Theory (EMTS 2013), Hiroshima, Japan. *Title of the session:* "Electromagnetic Theory," May 20–24, 2013.

Participated with an oral paper at the international conference Electromagnetic & Light Scattering (ELS-XIV 2013), Lille, France. *Title of the paper:* "EM scattering by a bounded obstacle in a parallel plate waveguide," June 17–21, 2013.

Participated in the workshop HF-13, Fårö, Sweden, August 11–14, 2013.

Participated at the Swedish National Conference on Radio Science (RVK13), The Royal Swedish Academy of Sciences, Stockholm, Sweden, November 11–12, 2013.

Participated at the workshop "Bra vetenskap och god moral till samhällets båtnad?" Kungl. Fysiografiska Sällskapet, Lund, Sweden, November 20, 2013.

Buon Kiong Lau:

Participated with two oral papers at the COST IC1004 6$^{\text{th}}$ Management Committee Meeting and Scientific Symposium, Malaga, Spain. *Titles of the papers:* "An efficient method of calculating signal correlation in lossy dipole arrays based on equivalent circuits" and "On the performance of adaptive impedance matching in MIMO terminals with different antenna characteristics," February 6–8, 2013.

Participated with two oral papers at the European Conference on Antennas and Propagation (EuCAP 2013), Göteborg, Sweden. *Title of the papers:* "Calculating signal correlation in lossy dipole arrays using scattering parameters

and efficiencies" and "Adaptive impedance matching performance of MIMO terminals with different bandwidth and isolation properties in realistic user scenarios," April 8–12, 2013.

Participated with an oral presentation at the 26th Annual Meeting of the Swedish Antenna Measurement Society (SAMS) in Linköping, Sweden. *Title of the presentation:* "Simple and Cost-effective Correlation Estimation of Lossy Multi-antennas," May 16, 2013.

Participated with one oral paper at the COST IC1004 7th Management Committee Meeting and Scientific Symposium, Ilmenau, Germany. *Title of the paper:* "Comparison of performance benefits from adaptive impedance matching for two MIMO terminals under a two-hand scenario", May 29–31, 2013.

Participated with three oral papers at the IEEE International Symposium on Antennas and Propagation (APS 2013), Orlando, Florida, USA. *Titles of the papers:* "On user effect compensation of MIMO terminals with adaptive impedance matching," "Design of multi-antenna feeding for MIMO terminals based on characteristic modes," and "Generating multiple characteristic modes below 1 GHz in small terminals for MIMO antenna design," July 7–13, 2013.

Participated with one oral paper at the COST IC1004 8th Management Committee Meeting and Scientific Symposium, Ghent, Belgium. *Title of the paper:* "Designing and feeding multiple characteristic modes in small terminals at frequencies below 1 GHz," September 25–27, 2013.

Daniel Sjöberg:

Participated with a presentation at the Workshop on Mathematical Modelling of Wave Phenomena 2013, Växjö, Sweden. *Title of the Paper:* "Determination of material parameters using different sample orientations in hollow waveguides," March 23–24, 2013.

Participated with an oral paper at the URSI International Symposium on Electromagnetic Theory (EMTS 2013), Hiroshima, Japan. *Title of the Paper:* "Material characterization in partially filled waveguide using inverse scattering and multiple sample orientations," May 20–24, 2013.

Participated with a presentation at the Progress in Electromagnetics Research Symposium (PIERS 2013), Stockholm, Sweden. *Title of the Paper:* "Using web quizzes to assess concept understanding and pacing the students," August 12–15, 2013.

Participated with two oral papers at the International Conference of Electromagnetics in Advanced Applications (ICEAA'13), Torino, Italy. *Titles of the Papers:* "A Sum Rule and Physical Bound for Electromagnetic Band Gap Structures," and "Local Problems for Homogenization of Periodic Thin Films," September 9–13, 2013.

5.6 Examination committees

Mats Gustafsson:

Member of the examination committee for Shuai Zhang, KTH, Stockholm, Sweden. *Title of the thesis:* "Investigating and Enhancing Performance of Multiple Antenna Systems in Compact MIMO/Diversity Terminals," January 28, 2013.

Member of the examination committee for Nima Jamaly, Chalmers, Göteborg, Sweden. *Title of the thesis:* "Multiport Antenna Systems for Space-Time Wireless Communications," April 5, 2013.

Member of the examination committee for Troels Vejle Hansen, DTU, Denmark. *Title of the thesis:* "Miniaturization of Spherical Magnetodielectric Antennas," November 22, 2013.

Buon Kiong Lau:

Member of examination committee for Ivan Bonev, Department of Electronic Systems, Aalborg University, Denmark. *Title of the thesis:* "Radiation Performance of Multi Antenna Terminals," August 23, 2013.

Member of examination committee for Samantha Caporal Del Barrio, Department of Electronic Systems, Aalborg University, Denmark. *Title of the thesis:* "Tunable Antennas to Address the LTE Bandwidth Challenge on Small Mobile Terminals: One World, One Radio," December 11, 2013.

Daniel Sjöberg:

Participated as external reviewer of the thesis by Jyoti Prasad Gogoi, Tezpur University, India. *Title of the thesis:* "Expanded Graphite-Novolac Phenolic Resin Based Electromagnetic Interference (EMI) Shielding Material Over the X-band: Synthesis, Characterization, Analysis and Design Optimization." Written statement sent to India, February 21, 2013.

Participated as evaluation committee member at the defence of Livia Cerullo, Chalmers University, Sweden. *Title of the thesis:* "Microwave Measurement System for In-Line 3D Monitoring of Pharmaceutical Processes," November 7, 2013.

5.7 Referee for international journals and conferences

Anders Derneryd:

IEEE Antennas and Wireless Propagation Letters

IEEE Transactions on Antenna and Propagation

IET Electronics Letters

Progress in Electromagnetic Research C

43nd European Microwave Conference (EuMC 2013)

Mats Gustafsson:

EuCAP 2013

IEEE Antennas and Wireless Propagation Letters

IEEE Transactions on Antenna and Propagation

Anders Karlsson:

ETRI Journal

IEEE Transactions on Antenna and Propagation (three times)

Gerhard Kristensson:

Wave Motion (as editor)

URSI International Symposium on Electromagnetic Theory (EMTS 2013)

Christer Larsson:

IEEE Antennas and Propagation Magazine

IEEE Transactions on Antenna and Propagation

IEEE Antennas and Wireless Propagation Letters

Buon Kiong Lau:

IEEE Transactions on Antenna and Propagation

IEEE Antennas and Wireless Propagation Letters

5th European Conference on Antennas and Propagation (EuCAP 2013)

5.8 Other activities

Buon Kiong Lau:

One book proposal review, John Wiley & Sons.

Daniel Sjöberg:

> Acted as external expert in the evaluation of applications for a position as Assistant Professor (biträdande lektor), KTH, Sweden. Meeting with the Board of Appointments September 5, 2013.

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6 Teaching Activities

6.1 Undergraduate teaching

The Electromagnetic Theory Group delivers courses in Circuit Theory and in Electromagnetic Field Theory. The students come from six educational programs: Engineering Physics (F), Electrical Engineering (E), Computer Science (D), Engineering Mathematics (Pi), Engineering Nanoscience (N), and Biomedical Engineering (BME). 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 program Wireless Communication (MWIR). An overview of the courses offered by the Electromagnetic Theory Group is shown in Figure 15.

The courses on advanced level, *i.e.*, ETEN05 Electromagnetic Wave Propagation, EITN10 Multiple Antenna Systems, ETEN10 Antenna Technology, ETEN15 Accelerators, Particles, and Fields, and ETEN01 Microwave Theory, are also offered as graduate courses as part of the PhD education.

6.1.1 Undergraduate courses given during 2013

Program[a]	**Name of the course**	**Lecturer**[b]
E1	Electronics	**Anders Karlsson**
		Alexander Bondarik
		Iman Vakili
		Marius Cismasu
		Doruk Tayli
		Gabriele Costanza
		Richard Lundin
F2, N2	Electromagnetics and Electronics	**Daniel Sjöberg**
		Mats Gustafsson
		Marius Cismasu
		Doruk Tayli
		Carl Gustafsson
		Andreas Ericsson
		Gabriele Costanza
E3	Electromagnetic Fields	**Buon Kiong Lau**
		Andreas Ericsson
F3	Electromagnetic Field Theory	**Gerhard Kristensson**
		Gerhard Kristensson
		Gabriele Costanza
		Iman Vakili
Pi3	Electromagnetic Field Theory	**Gerhard Kristensson**
		Gerhard Kristensson
		Iman Vakili
E4, F4, Pi4, MWIR1, MFOT1	Antenna Technology	**Mats Gustafsson**
		Marius Cismasu
E4, F4, Pi4	Electromagnetic Wave Propagation	**Daniel Sjöberg**
		Doruk Tayli
E4, F4, Pi4	Microwave Theory[c]	
E4, F4, Pi4	Accelerators, particles, and fields	**Anders Karlsson**
		Richard Lundin
IDA2	Technical Interfaces[d]	Daniel Sjöberg
IEA2	Circuits and Measurements, Advanced Course[e]	Daniel Sjöberg

[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.

[c] Due to sick leave, the course Microwave Theory was canceled this year. However, three students took on the course as self studies, aided by Gabriele Costanza, Gerhard Kristensson, and Anders Karlsson.

[d] Course given at Helsingborg.

[e] Course given at Helsingborg.

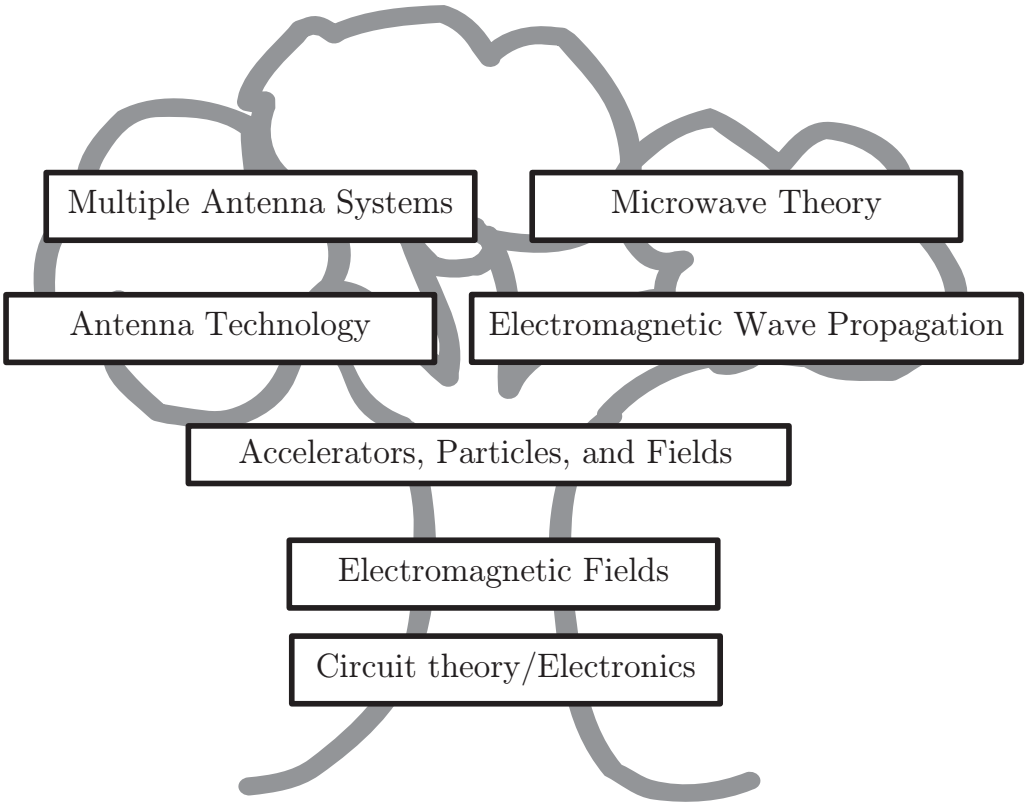

Figure 15: The undergraduate courses given by the Electromagnetic Theory group.

6.1.2 A brief presentation of the courses

ESS010 Electronics (15 ECTS credits, 110 hours):
Given to first year students on the Electrical Engineering, or E-, program. Approximately 100 students.
Course literature: Hambley, "Electric Engineering," Pearson, 2008; "Kretsteori, ellära och elektronik, exempelsamling," 2013.

ETE115 Electromagnetics and Electronics (7.5 ECTS credits, 62 hours):
Given to second year students on the Engineering Physics, Engineering Nanoscience, and Biomedical Engineering, or F-, N-, and BME-programs. Approximately 120 students.
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," 2013.

ESS050 Electromagnetic Fields (9 ECTS credits, 84 hours):
Given to third year students on the Electrical Engineering, or E-, program. Approximately 75 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.
General electromagnetic fields: The Maxwell equations. Plane waves. Retarded potentials. Radiation fields from known sources and simple antennas. The Poynting vector.
Course literature: David K. Cheng, "Field and Wave Electromagnetics," (2nd Edition, Pearson New International Edition), Pearson, 2013; problem collection, KF Sigma 2002.

ETE055 Electromagnetic Field Theory (6 ECTS credits, 56 hours):
Given to third year students on the Engineering Physics program. Approximately 90 students.
The course is an introductory course in the basic electro-static and magneto-static problems. Covering the basic laws such as Coulomb's and Biot-Savart's laws. The latter part of the course covers 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 to third year students on the Engineering Mathematics program. Approximately 40 students.
The course is an introductory course in the basic electro-static and magneto-static problems. Covering the basic laws such as Coulomb's and Biot-Savart's laws. The latter part of the course covers 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.

ETEN10 Antenna technology (7.5 ECTS credits, 50 hours):
Given to fourth year students on the Engineering Physics, Electrical Engineering, and Engineering Mathematics, or F-, E-, and Pi-programs, and the international master program Wireless Communication (MWER). Approximately 40 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 to fourth year students on the Engineering Physics, Electrical Engineering, and Engineering Mathematics, or F-, E-, and Pi-programs. Approximately 20 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 to fourth year students on 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, 2013.

ETEN15 Accelerators, Particles, and Fields (7.5 ECTS credits, 28 hours):
Given to fourth year students in the Engineering Physics, Electrical Engineering, and Engineering Mathematics programmes. Approximately 10 students.
The course describes the electrodynamics involved at the major accelerator facilities in Lund, MAX-lab and ESS. Some specific examples are calculation of the trajectories of particles in electromagnetic fields, steering of charged particles, synchrotron radiation, the fields generated by an arbitrarily moving charged particle, Cherenkov radiation, transformation of fields between inertial frames, the theory of relativity, superconductors, the method of images, storage rings for electrons, linear accelerators, numerical calculation using a finite element program.
Course literature: Parts from Griffiths D J, "Introduction to Electrodynamics", Prentice Hall. Additional material as handouts.

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. 2013.

Anders Karlsson, Gerhard Kristensson:

Microwave theory. 2013.

6.4 Graduate courses

Mats Gustafsson, Daniel Sjöberg, Christer Larsson, Anders J. Johansson, and Henrik Sjöland:

EIT100F Design, build, and test a radar system, 7.5 Credit units.

Gerhard Kristensson:

PHD002 Electromagnetic Theory, 12 credit units.

Rebecca Saviour:

Photonic crystals, spring 2013.

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7 Official Commissions

7.1 Official scientific committees

Anders Derneryd:

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

Mats Gustafsson:

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

Member of the Technical Program Committee at the 7$^{\text{th}}$ European Conference on antennas and Propagation (EuCAP 2013).

Member of the technical program Committee at Progress in Electromagnetics Research Symposium (PIERS).

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*.

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".

Member of the evauation board of INRA, France.

Board member of the IEEE MTT/AP Chapter of Sweden

Christer Larsson:

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

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).

Coordinator of the 2013 Student Design Contest of the Antennas and Propagation Society, IEEE.

Associate Editor of the IEEE Transactions on Antennas and Propagation.

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

Regional Delegate of European Association on Antennas and Propagation (EurAAP, `http://www.euraap.org/`) for Region 6 (Iceland, Norway, Sweden).

Technical Program Committee (TPC) Member for:

1. 2013 European Conference on Antennas and Propagation, Göteborg (EuCAP), Sweden, 8–12 April, 2013 (involving 61 meta-reviews of 2-page abstracts and 61 full paper reviews).
2. 2013 International Workshop on Antenna Technology (iWAT), Karlsruhe, Germany, 4–6 March, 2013.
3. IEEE 77th Vehicular Technology Conference (VTC)-Spring, Dresden, Germany, 2–5 June, 2013.
4. IEEE International Conference on Communications (ICC), Budapest, Hungary, 9–13 June, 2013.
5. IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), London, UK, 8–11 September, 2013.
6. 2013 Loughborough Antennas and Propagation Conference (LAPC), Loughborough, UK, 11–12 November, 2013.

Reviewer for the French National Research Agency (ANR).

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:

Capacity group leader of the Electromagnetic Theory Group.

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.