Complex analysis and convex optimization for optimal and automated design of electromagnetic structures

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Workshop schedule for January 14, 2015 in E:3139

9.15	MG	Introduction
9.30	RS	Complex analysis in several variables
10.00	AL	Herglotz functions and several variables
10.30		Coffee break
11.00	LJ	Passive systems and Herglotz functions
11.30	*	Applications of Herglotz functions
12.00		Lunch
13.30	DS	Sum rules and convex optimization
14.00	*	Approximations of Herglotz functions
14.30	SN	EM modeling and power cables
15.00		Coffee break
15.30	MG	EM energy and antennas
16.00	AS	Optimal W-BAN antennas
16.30	*	'Nyttiggörande'
17.00	MG	Summary
18.30		Dinner

∗-discussions.

Complex analysis in several variables

Ragnar Sigurðsson

In the talk I will describe how some the concepts of complex analysis in one variable generalize to several several variables. Some results are exactly the same in one and several variables, but others are different, and a lot of new concepts appear that have no meaning for functions of one variable. The residue theorem, which we all love so much, does not generalize so easily to several variables and we do not have a technique for evaluating integrals and sums similar to the residue calculus.

I will look at the classes of holomorphic (analytic), harmonic and subharmonic functions on open sets in $\mathbb{C}$ and describe the corresponding generalizations on open sets in $\mathbb{C}^n$. Finally, I will say a few words about Hörmander's existence theory for the Cauchy-Riemann system, which is a very strong tool to construct holomorphic functions of several complex variables.

Herglotz functions and several variables

Annemarie Luger

Herglotz functions, i.e. functions mapping the complex upper half plane holomorphically into itself, are very useful when working with passive systems. However, in this classical setup one can deal with one variable only, usually the frequency. In order to be able to include also other parameters (such as angle, ???) Herglotz functions in several variables have to be considered.

In this talk we give an overview on what we know so far about the main analytic tool, namely integral representations, for such functions in several variables.

Passive systems and Herglotz functions

Lars Jonsson

In this talk, we begin with a review of a few known passive system from Electromagnetic theory. These systems are time-convolution system described with a scalar-valued kernel. Passivity of such systems imply that the kernel have attractive properties (e.g. it is a Herglotz function, a positive real-function or similar), and this information has been utilized to obtain limitations on its bandwidth behavior through a sum-rule result. As a second step, we study a larger class of convolution systems, where the convolution is in space-time. Our goal here is to discuss how passivity carry over and if that property is sufficient to obtain physical bounds about such generalized system. If time permit we will also discuss matrix and operator valued convolution systems.

Sum rules and convex optimization

Daniel Sjöberg

Any passive, linear, time translational invariant system can be associated with a Herglotz function. It is possible to derive a powerful representation formula for Herglotz functions, which enables the representation and approximation of any such system to an arbitrary accuracy. This makes it possible to investigate the best possible realization of a given desired system performance. We give a number of examples for situations like negative refractive index, high impedance surfaces, dispersion compensation etc.

EM modeling and power cables

Sven Nordebo

The project is concerned with modeling and analysis regarding the wave propagation characteristics of power cables. Important application areas are with fault localization and monitoring, transient signal analysis and partial discharge diagnostics. Electromagnetic modeling also has a potential application with optimal electromagnetic design by accurately predicting the losses of high-voltage AC power cables. Presently the project focuses on the electromagnetic modeling of helical waveguide structures (such as a three-phase AC cable) by employing a volume integral formulation in Fourier space. The formulation is based on the periodic free space Greens function together with an efficient use of the helical structure and its Fourier description. The spectral properties of the corresponding singular integral operator is of mathematical interest, i.e., the question if analytic Fredholm theory or any other similar results can be applied? The project will also address the inverse problem of estimating material dispersion

EM energy and antennas

Mats Gustafsson

The stored electromagnetic energy of an antenna is used to determine the antenna Q. The stored energy can be estimated from the input impedance of the antenna, the electromagnetic fields around the antenna, and the current densities in the antenna structure.
Antenna current optimization offers performance bounds and suggestions for the distribution of the desired antenna currents. Many current optimization problems can be formulated as convex optimization problems that are solved efficiently with explicit error bounds. In this presentation, we discuss

- stored energy defined from the fields, currents and imput impedance.
- energy for PR/Herglotz functions.
- applications in antenna optimization.

Embedded antennas

Anja Skrivervik

Antennas are an important element of Wireless Body Area Network equipments, as the quality of the antenna and its coupling to the channel will be a key component of the quality of the overall link. Indeed, the antenna and its interaction with the body of the wearer will influence the reading distance, the emitted or received power, but also issues like the specific absorption rate. The design of an efficient antenna is thus one of the keys to the design of an efficient W-BAN links. In this presentation, the specificities of antennas dedicated to W-BAN applications will be reviewed, and then some design rules will be proposed.

E:3139 (southwest corner, third floor in the E-building)