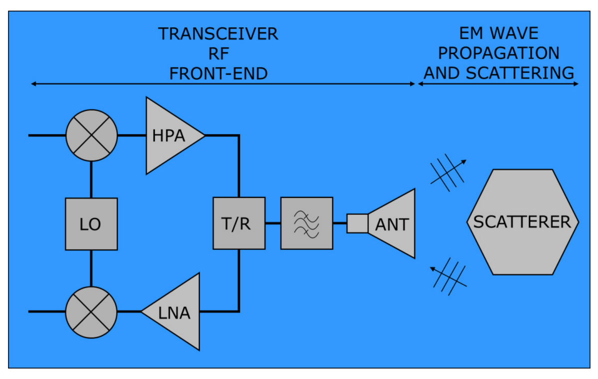
Electromagnetic Systems
Department of Electrical Engineering



DTU

M.Sc. Projects by Electromagnetic Systems

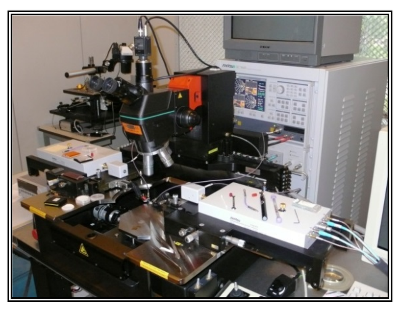
RESEARCH AREAS

We cover radio front-end technology, as well as radiation, propagation, and scattering of electromagnetic waves. Our research ranges from theory, numerical and experimental techniques to components, circuits, and systems. Traditionally, most research has been in the microwave frequency range, 300 MHz - 300 GHz, which continues to be central, but we are also engaged in projects at lower (VHF) as well as higher (THz) frequencies. Some specific areas are listed below.

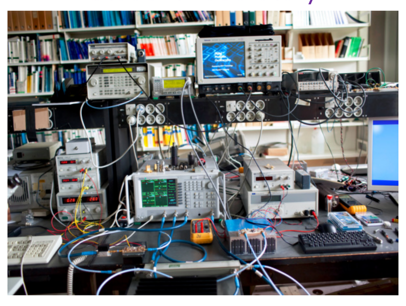
- Structured electromagnetic materials – metamaterials, metasurfaces, plasmonic structures, photonic crystals, homogenization
- Electrically small antennas - hearing aid antennas, super-directive antennas, 3D-printed antennas, nano-antennas
- Satellite antennas - reflectarrays, reflector antennas, cubesat antennas, 3D-printed antennas
- Near-field antenna measurements - high-accuracy testing, antenna diagnostics, phase-less measurements, mm-wave measurements, validation standard antennas, probe antennas
- Computational electromagnetics – analytic techniques, numerical techniques, integral equation method of moments, direct and inverse scattering methods
- Medical imaging - microwave imaging, magnetic resonance RF/ microwave instrumentation
- Millimetre wave and sub-millimetre wave MMIC - design, modelling, solid-state components, high-speed interconnects

DTU-ESA Facility

110 GHz VNA



Student Laboratory



WHO ARE WE?

Personnel – 25 in total

- 6 faculty professors & 1 research professor
- 2 research assistants
- 11 Ph.D. students
- 4 TAP & 1 group secretary

Collaborators

- Cobham /Thrane & Thrane
- WIDEX
- GN Resound
- Weibel Scientific
- Qorvo
- Mellanox Technologies
- TICRA
- Teknologisk institut
- ESA
- EADS CASA
- …

- DTU Space
- DTU Fotonik
- DTU Nanotech
- DTU Compute

- University of Arizona, USA
- University of Mississippi, USA
- EPFL, CH
- …

POTENTIAL MSc. PROJECTS

1. Quantum Dot Assisted Nano Antennas
This project investigates numerically the resonant properties of plasmonic-based coated nano-rods impregnated with realistic quantum dot gain materials. Structures are identified for which the structural resonances coincide with the emission resonances of quantum dots in order to boost their radiation and scattering characteristics. Realistic materials (e.g., silver) will be used. Attention will be devoted to the ability of nano antennas to provide directive near- and far-field radiation.

2. Water-Based Platforms for Effecient Wave-Matter Interactions
Several material platforms, e.g., metasurfaces, exists that can tailor reflection, tranmission, and absorption of waves in any desirable way. Often, rather complex and expensive designs are employed. In this project, we examine, theoretically and experimentally, the potential of simple water as basic element for efficient metasurfaces and antennas for sensing applications. Attention is focused on simple and highly tunable water-based platforms for enhanced/reduced wave interaction.

3. RF probe for MRI systems
In this project the students will design, construct, and test their own probe (coil) for Magnetic Resonance Imaging (MRI). You will gain theoretical and practical knowledge about radio frequency (RF) coil design for both: animal and human imaging. The imaging properties of the coils will be tested on MR scanners in Hvidovre Hospital. We expect that you have background in electromagnetics and high frequency electronics.

4. Solid State Signal Sources
Nuclear magnetic resonance (NMR) is one of the most powerful analytical techniques with applications in physics, chemistry, biology and medicine. High signal to noise ratio in NMR spectroscopy and imaging is achieved by hyperpolarization - transfer of polarization from electrons to nuclei. This process requires continuous microwave irradiation. In this project an efficient high power microwave source ($f \approx 100$ GHz) should be built. It is based on low frequency phase locked loop oscillator followed by a chain of frequency multipliers. The multipliers will make use of varactor diodes.

5. Electromagnetic Sources for Microwave Imaging for Brain Stroke Monitoring
The goal of this project is the enhancement of a existing simulation tool with different antenna radiation patterns. The project starts with the implementation of the radiation pattern (electric and magnetic field) of a dipole that can be at any arbitrary position and distance around the head.

6. Multigrid Techniques Applied to Volume Integral Equations
The goal of this project is the application of multigrid techniques to the solution of volume integral equations. In this framework multigrid techniques should be studied with respect to discretizing a given problem using voxels and to solving the resulting linear equation in combination with iterative solvers, e.g. Netwon's method.

7. Interferometric Inversion for Brain Imaging
Instead of fitting simulated data directly to measured data, superposition of measured data can greatly improve the imaging quality and the stability of the inversion algorithm. In this project, the application of interferometric inversion in the framework of brain imaging should be tested. For this, an existing inversion algorithm should be enhanced and the implemented interferometric inversion tested against the original algorithm for several test cases.

8. An InP DHBT Large-Signal Model with Increased Accuracy in the Saturation Region
It is known that the InP Double Heterojunction Bipolar Transistors (DHBTs) may suffer from a current induced conduction band barrier at the base-collector heterojunction. This effect is known to "soften" the knee region of the Ic-Vce characteristics and is called the "soft knee effect". Available approaches to model the soft knee effect are at best approximate. In this project, the student should analyze the physical structure of the composite collector region found in InP DHBTs and develop a better descritpion for the "soft knee effect". The outcome should be a compact model implemented in the commercial software tool "Advanced Design System". The developed compact model should be verified against measurements on large-signal circuits such as frequency multipliers and power amplifiers.

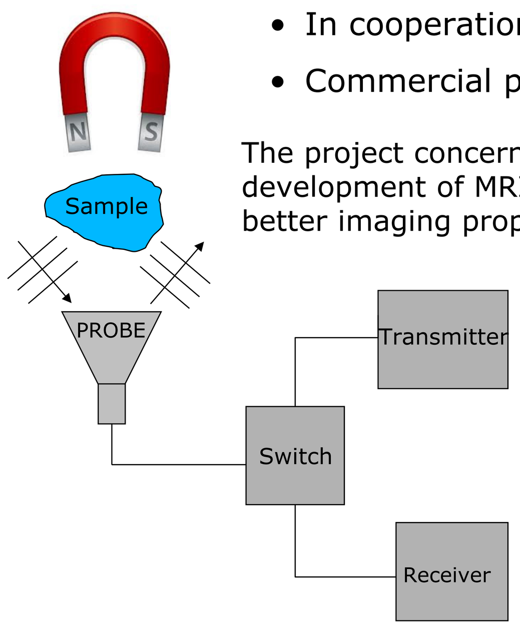
9. Design and Layout of a 140 GHz Integrated Power Amplifier by Thin-Film Microstrip Lines
In this project the student should investigate thin-film microstrip lines in an integrated InP Double Heterojunction Bipolar Transistor (DHBT) technology. The possibility of using thin-film microstrip lines as the interconnection strategy for millimeter-wave power amplifiers at 140 GHz should be accessed. Loss-loss power combining structures should be designed for increased output power levels.

10. Dual-Port Patch Antenna
This project aims at design, manufacture and test of a dual-port patch antenna with two orthogonal linear polarizations. The patch must be augmented with an exterior structure for increased directivity in order to obtain a gain of at least 10 dB while maintaining strict pattern properties. The project lies within the research on spherical near-field antenna measurements of the Electromagnetic Systems group and will involve work at the DTU-ESA Spherical Near-Field Antenna Test Facility.

11. Measurement Technique for Generator Input Reflection Coefficient
This project aims at developing and testing a technique and procedure for accurate measurement of the input reflection coefficient of an active microwave signal generator. This reflection coefficient cannot be measured directly by use of a VNA, but it is essential for high-accuracy gain calibration. The project lies within the research on spherical near-field antenna measurements of the Electromagnetic Systems group and is related to an on-going project for the European Space Agency.

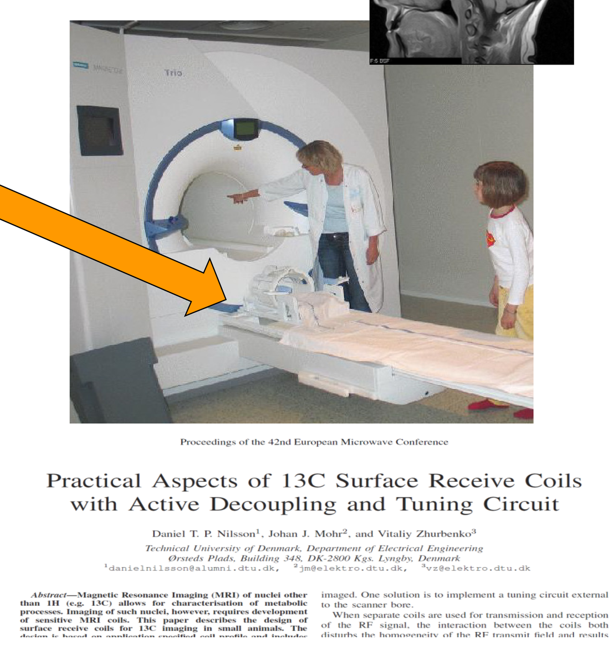
12. Phase Center Determination from Spherical Wave Expansion
This project aims at developing an efficient algorithm for calculation of the phase center(s) of an antenna from the spherical wave expansion of the antenna radiated field, and to implement this algorithm in a computer programe for use at the DTU-ESA Spherical Near-Field Antenna Test Facility. The project involves theory, programming, and testing with experimental and simulated data and lies within the research on antenna measurements of the Electromagnetic Systems group.

RF probe for MRI systems



- In cooperation with Hvidovre hospital
- Commercial potential

The project concerns the development of MRI probes with better imaging properties.



Last project resulted in a scientific publication !

Contact: Vitaliy Zhurbenko

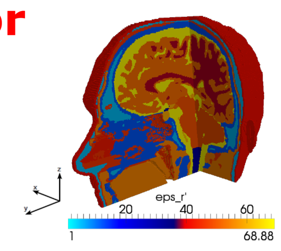
Your background: Electromagnetics, HF electronics

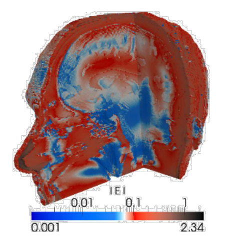
Electromagnetic Sources for Microwave Imaging for Brain Stroke Monitoring

Microwave Imaging (MWI) is an active technique used to localize and reconstruct an unknown scene by means of interrogating microwaves. Lately, attention was brought to the possibility of applying MWI to monitor brain stroke related diseases.

Current clinical imaging methods, such as MRI or CT offer useful information on tissue properties and therefore are good tools for assessing diseases such as brain strokes. However, none of these facilities can be widely available at bedside in emergency departments or in paramedical services such as ambulances. MWI is a promising technique that has the potential to fill these gaps.

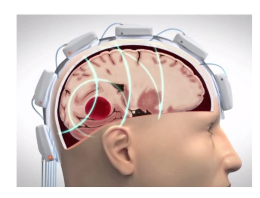
Very often, **plane wave illumination** is considered in imaging techniques. However, in MWI the emitting and receiving antennas are directly placed on the patient's head. Therefore, the scatterer (head) is located in the near-field of the surrounding antennas.



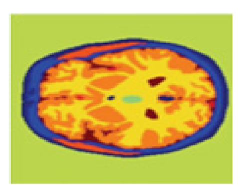


Project objectives

The goal of this project is the enhancement of a existing simulation tool with different antenna radiation patterns. The project starts with the implementation of the radiation pattern (electric and magnetic field) of a dipole that can be at any arbitrary position and distance around the head.



Your background: Advanced EM, Antennas, Numerical Methods, Programming



Project content

- Overview of the MWI (20%)
- Development and implementation (preferable Python) of different radiation patterns starting with the electric dipole (50%)
- Testing (20%)
- Documentation and reporting (10%)

Contact: Michael Mattes

13. Fano Resonances in Microwave Microstrip Structures
This project aims at design, manufacture, and test of microstrip resonating structures that possess so-called Fano resonances at microwave frequencies. The purpose is to understand the physical mechanisms of the Fano resonances, to establish design guidelines for generating these, and to investigate their potential limits. This project relates to on-going research of the Electromagnetic Systems group on Fano resonances at optical frequencies in nano-photonic components.

14. Microwave and Antenna Technology for Wireless Communications
These are broad areas of research within which several specific projects can be defined. Please note that the specific project description is subject for discussion with the student(s), so that emphasis may be placed on either theoretical or more practical aspects of the subject.

15. Electromagnetic Systems for Biomedical Applications
EMS carrying out several projects in the field of electromagnetic systems for biomedical applications. These mainly include microwave imaging for breast cancer detection and RF components for MR imaging. Several projects are available in this area. Please contact us for detailed description. We expect that you have background in electromagnetics and high frequency electronics.

DTU Electrical Engineering
MSc. project day
2017

Contact:
Samel Arslanagić
Bldg. 348 / 214
sar@elektro.dtu.dk