Microwave Laboratory

The **Microwave Laboratory** of the Christian Albrechts University of Kiel (CAU) has continued research in the areas of **ultra-wideband technology (UWB)**, **power amplifiers for communication systems**, and **high frequency materials and components**. The working area of **microwave sensors**, where highly regarded research has been carried out during the last few decades, has been further extended to field based sensors, which include for example eddy current sensors, low frequency capacitive sensors and magnetoelectric sensors. Another working area is **molecular spectroscopy**, where work on spectrometer construction continues.

UWB-technology concentrates on sensors for the characterization of condition, composition and history of natural materials. The research is presently focused on non-contacting determination of the properties of dielectric objects. Over the years the laboratory has aquired considerable expertise in the application of dielectric spectroscopy and in the use of multivariate statistics to analyse the response of UWB signals.

The work on **power amplifier (PA) principles** is mainly concerned with so-called sequential amplifiers and outphasing amplifiers. Sequential amplifiers were investigated with respect to efficiency and linearity. Some work has been devoted to a novel approach of linearization by predistortion. Outphasing amplifiers have also been investigated for many years in this laboratory. Present work concentrates on special power combiners and PA linearization.

Industrial microwave sensors is an area, where the microwave laboratory has a long established experience. A wide range of sensors has been created in the past. Present work concentrates on millimeter wave doppler radar sensors for the characterization of, for example aerosols, on other radar sensors and on sensors for medical applications. Significant effort has been devoted to investigations concerning the characterisation of magnetoelectric sensors and to low noise electronic circuits for interrogating such devices.

The working area **Materials and high frequency components** is focused on various characterization methods for the determination of the permeability of magnetic nanocomposites at frequencies up to several GHz. The materials are then applied in components such as inductors or balun transformers at microwave frequencies. Close cooperation exists in this area with the materials research at CAU Kiel.

Molecular spectroscopy is focused on spectroscopy itself, but also on the development of new spectrometers in the millimeter and sub-millimeter wave region.

Results

Non-Contacting Characterisation of the Dielectric Properties of Objects of Irregular Shape

The aim of the DFG-project ISOPerm (irregular shaped objects permittivity) is to develop an UWB method for the measurement of the dielectric properties of irregularly shaped bodies by using a non-contacting approach. Industrial processes often require the determination of e.g. the water content of bulk materials and other process parameters. There is a strong correlation between many of those quantities and the dielectric properties. Therefore, dielectric measurements are well-suited for material characterization. Existing methods for such measurements require that the samples are regular in shape. They also require that the entire cross section of the electromagnetic field which is used is filled with the material under test. The method under development does not require the restrictions. Contrary to existing methods and as a novel approach an attempt was made using multivariate analysis, to separate effects caused by to the geometry of the object from those caused by to its dielectric properties. It was successfully proved with simulations and measurements of dielectric objects and the use of multivariate analysis methods that the determination of the dielectric properties is possible independent of shape, size and orientation to a certain accuracy. It was also shown that related properties like e.g. the water content of water-ethanol mixtures or the carbon content of carbon loaded silicones can be determined directly from time domain data. The multivariate analysis methods can be improved by a prior classification algorithm which classifies

into dielectric classes, e.g. high and low dielectric constant. The statistical models applied for each class are more accurate in comparison to statistical models for the whole dielectric range. Further investigations will focus on the demonstration of a stand-alone sensor system which will comprise the development of the prototype of a practical apparatus capable of working in real time. This will reveal the system performance and accuracy under practical conditions.

Magnetic Nanocomposites for RF-Applications

In cooperation with the Multicomponent Materials chair, the Inorganic Functional Materials chair and Nanoelectronics group novel magnetic and magnetoelectric materials were characterized by measurements. Further, analytical expressions for modelling these materials were found. The measured permeability spectrum was used to calculate the unknown material parameters by using a nonlinear regression algorithm.

Furthermore a new approach for the design of baluns with magnetic cores was introduced. The investigations have the ojective to fulfil the demands of small size, wide operation bandwidth, and low loss, required for modern mobile communication and electronic systems. Baluns were designed using HFSS and will be realized in thin-film technology with various core designs to avoid eddy currents and minimize parasitic capacitances.

Heterotopic Bone Induction

When the jaw bone is affected by cancer the diseased areas need to be removed. Today these removed parts are filled by tissue from the thigh bone. This procedure has the disadvantage the the thigh bone becomes more fragile. In this project another way is pursued: A matrix of calcium apatite is manufactured by a 3D-plotter in a way that the shape perfectly matches into the gap of the removed tissue. This matrix is provisionally transplanted into a muscle. Stems colonize the matrix which has the structure of a sponge. When growth factors are injected into the matrix a vascularisation process starts and the tissue built by the stems is nourished.

After a period from 12 to 16 weeks the matrix is steeped by new induced cartilage and bone tissue. The new bone piece is now ready to be transplanted into the gap in the jaw. The advantage of the described method is that the tissue is produced by the patient and therefore there is no rejection by the immune defense. A disadvantage of heterotopic bone induction is that the growth factors may cause cancer. Hence the drug dose should be as small as possible. In order to optimise the ossification a regularly monitoring is needed.

For this purpose an eddy current sensor is developed in the microwave laboratory. The principles of eddy current sensors are well known and they are established in metal detectors. The challenge in this application is that the conductivities of the involved tissues are relatively low in comparison to metals by a factor of a million. Furthermore the difference in conductivity between bone tissue and body fluid (filling the sponge of calcium apatite) is relatively small. Because the sensor works with magnetic fields it can measure tissues behind the skin and therefore there is no need to make any injuries. The results of the measurements are available immediately. Hence the progress of the ossification can be monitored continuously without any risks of infections.

On the basis of simulations the structure of the sensor was optimised and a suitable frequency was found. A prototype was built and first measurements lead to encouraging results. In the future the sensor will be evaluated in animal testings. This project is carried out together with the Department of Oral and Maxillofacial Surgery of the Clinical Center of the Christian-Albrechts-University.

Collaborative Research Centre SFB 855 ''Magnetoelectric Composite Materials - Biomagnetic Interfaces of the Future''
Subproject C3: Sensor Modelling and Electronic Signal Processing

The aim of the collaborative research centre SFB 855 is the development of a highly sensitive magnetoelectric (ME) detection unit that is able to measure biomagnetic signals in the picotesla region. Previous noise calculations of sensor and a readout electronic were verified by noise measurements. A system noise level as low as 7.5 pT/$\sqrt{\text{Hz}}$ and magnetic signals down to 10 pT were measured. Moreover a ME modulation technique was conceived and developed to reach a

high system sensitivity outside the sensor resonance. This technique allows sensitive broadband measurements below 100 Hz as required for biomagnetic diagnostics in magnetoencephalography (MEG) and magnetocardiography (MCG). Another working point was the detection of magnetic fields caused by pacemaker signals. Therefore a compact magnetometer was developed and simulations and measurements were carried out. Furthermore a non-magnetic scanner was designed to allow a 3 dimensional movement of the sensor.

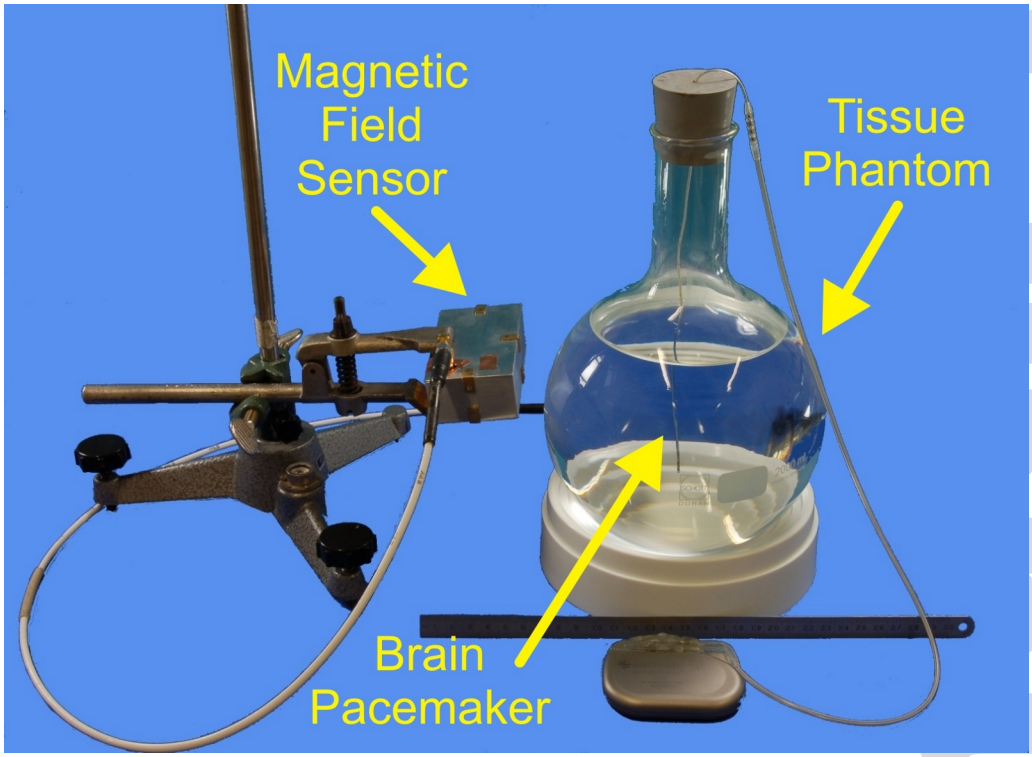

Fig. 1: Measurement of the magnetic field of a brain pace maker in a phantom head

PITAS

The PITAS-project is a common activity of the maritime cluster in Kiel and the chairs of „Circuit- and System Theory, (Prof. Heute)“ , „Information and Coding theory, (Prof. Höher)“ , „Microwave group, (Prof. Knöchel)“ from the Institute of Electrical Engineering and Information Theory, and the chair of „Information Systems Engineering, (Prof. Klein)“ from the Institute of Computer Science. It addresses attacks of piracy and terrorists to civilian ships. Background of the described subproject is the radar surveillance of the near range of less than e.g. one mile around ships for identifying approaching threats like attacking pirates in order to achieve an early warning of the ship's crew. Various low cost near range radar concepts have been investigated with respect to their suitability to be used on ships. One of those concepts was the near range surveillance using van Atta-arrays. Such radar allows high speed tracking of near range targets like e.g. bullets. It turned out, that the van Atta array requires considerable effort in order to offer the required spatial resolution and thus leads to quite complex and costly systems. It has therefore been abandoned for the purpose of tracking swimmers and speed boats.

Radar-Sensor for the detection of dust

A double frequency radar method for remote sensing of disperse streams of solid particles was developed. The method is based on measuring a differential radar cross-section of a moving particle ensemble, and permits to estimate parameters of particle size distribution for different types of disperse streams. The developed method was tested on generated disperse stream of calibrated solid particles using a specially developed double-frequency radar-sensor in Ka- and W-band. The

obtained experimental data show a good agreement with the simulated results. This allows the method to be used in sensors for industrial emission monitoring, volcano eruption control, dust storm forecast, etc.

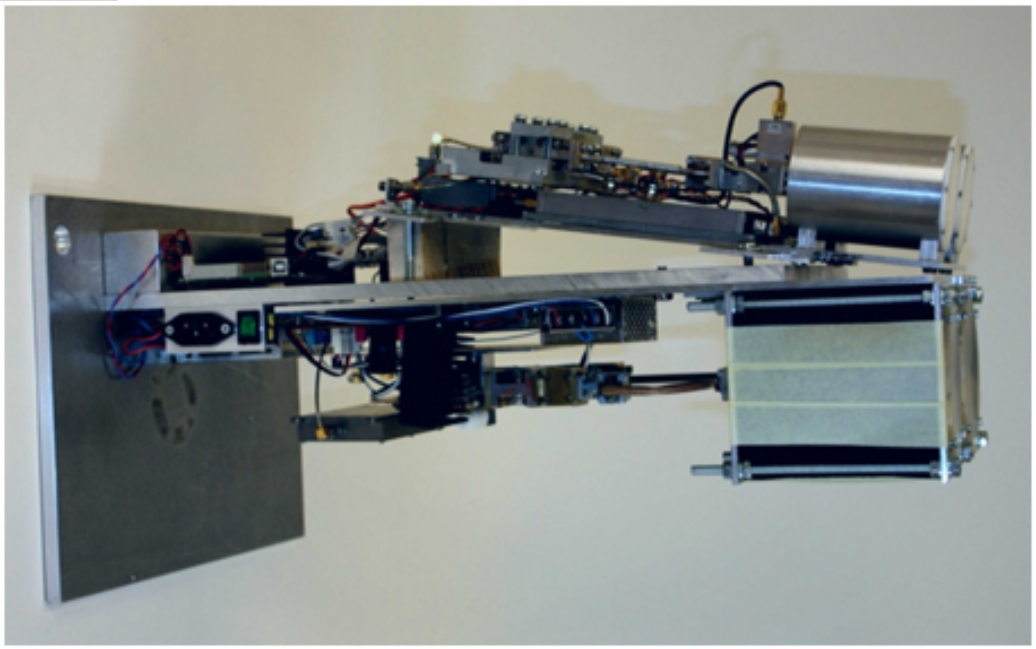

Fig. 2: Double-frequency radar-sensor

Metamaterial Loaded Slow Wave Structures

In order to improve the characteristics of a spatial harmonic magnetron (SHM), the slow wave structure (SWS) of these devices has been loaded by different types of metamaterials. It has been shown that loading the SWS by a negative permeability medium (MNG) can provide the possibility of increasing the efficiency of these devices together with the possibility of increasing the SWS dimensions which is very important in millimeter wave range.

Metamaterial Loaded Sensors

Solving Maxwells equations in a cylindrical waveguide which has been filled by anisotropic medium clarifies the possibility of establishing the idea of a virtual short circuit. This virtual short can be used to confine the energy at the open end of a cylindrical TE011 moisture sensor while it blocks only a very small part of the open end. In conventional sensors 75% of the open end should be covered by copper in order to avoid radiation. This has two drawbacks: the first one is a pertubation of the gas flow and the second one is a contamination of the end parts which will affect considerably the quality factor and therefore the accuracy of measurement.

Metamaterial Loaded Resonators

In 2002 it has been shown by N. Engheta that loading a slab waveguide with a metamaterial layer can provide the possibility of designing very thin (but only in width) sub-wavelength resonators. Using this idea together with a rigorous analysis of a circular wave guide which has been partially loaded by anisotropic metamaterial layer, a very small coaxial cylindrical cavity resonator loaded by an anisotropic metamaterial (6mm radius and 3.1mm height while the resonant frequency is 4.9GHz) was realized and simulated. This resonator eliminats the draw back of metamaterial loaded slab waveguide resonators which are small in width but not in length.

Microstrip Filter Design with Fuzzy Logic

Using time consuming full wave simulations and numerical analysis in electromagnetics problems is unavoidable if an

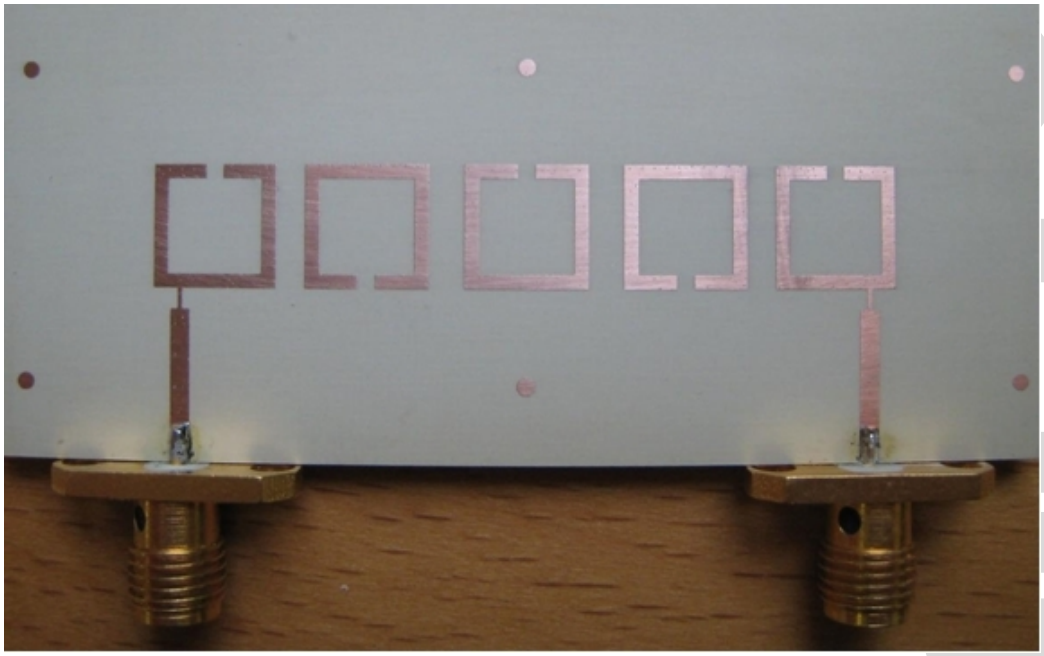

Fig. 3: Open loop resonator filter. The design parameters are extracted using the fuzzy method.

exact solution is required. From the perspective of an engineer a trade off between time and accuracy needs to be found. Sometimes an estimation of the solution with acceptable approximations which has been calculated by a pocket calculator is more valuable than a time consuming simulation. In this research it is tried to find a fast and accurate method for the time consuming full wave analysis of a desired filter coupling matrix. This approach makes the filter design process vanishingly short. To reach the above mentioned goal a novel fuzzy based approach has been used to overcome the drawbacks of common approaches. The advantage of the method is mimicking the human brain approach when it encounters a new problem. Therefore a complicated view to the problem is substituted by a simple view to it. Thus the method has a simple formulation and a pattern-based processing instead of using complicated models. The approach remains unchanged whether the problem is complicated or simple because it tries to imagine each multi-input single-output (MISO) system is a combination of some single-input single-output (SISO) one. The behavior of each SISO system is extracted by the new method and then the total behavior of the system is extracted by a proper combination rule of inference. The method has been tested in designing open loop microstrip filters with rectangular and triangular structures. The modeling has been completed for two and three independent variables affecting coupling factor and external quality factors. A fabrication and characterisation of five different filters (different structures and different filtering characteristics) has confirmed the accuracy and fastness of the method. Higher numbers of independent variables affecting coupling factor and external quality factor will be modeled in the next steps. The ability of the method in designing other different structures rather than microstrip open loop resonator filter is currently investigated.

UWB Through-Wall-Radar

An application of an UWB radar system with a breath simulator (UWBSBS) for remote measurement of the position and respiration of hidden persons in varying positions and angles was finished. A suitable reference system was provided by the breath simulator. The system can control the frequency of simulated human breath and measures it at the same time. The measurements have been done in a given area with 120 measurement points. The whole process of life detection in this case was also carried out automatically. The analysis of these measurements has been accomplished and led to encouraging results.

Molecular Spectroscopy

Molecular spectroscopy in the range of millimeter- and submillimeter wavelengths (carried out by Prof. Guarnieri) allows the investigation of free molecules in the gas phase. In this state the molecules are in continuous motion proportional to their thermal energy. A part of this energy is stored as rotational energy. The activity of the lab was concentrated on the improvement of the resolution of the millimeter- and submillimeter wave spectrometer to allow very precise measurements of transition frequencies between rotational energy states. Astronomical observations in millimeter- and submillimeter wavelengths have led to the discovery of many different molecules in the interstellar clouds. Laboratory spectra of such molecules in the millimeter- and submillimeter range measured with a precision $\leq$ 1 kHz are therefore needed for modern astrophysical investigations. To this purpose this laboratory's spectrometer has been supplemented with devices that have allowed the observation of absorption lines with lamb-dip (a result of a saturated absorption process) accuracy. This method allows the measurement of the absorption lines with a precision $\leq$ 1 kHz. A corresponding paper was published in 2007 in Astrophysics Letters. Further to increase the sensitivity of the InSb-Detector-chip in the frequency range near 1 THz (0,1 m/m wavelength) a suitable cryostat provided with a superconducting magnet, delivering by 4K a magnetic field of 1 Tesla around the InSb-chip, is under construction in the local workshop of the faculty. Within the scope of the DFG-cooperation project (official ending shifted to 2011) with the Institute of Applied Physics of the Russian Academy of Science (Nizhnii Novgorod) spectra of the HCCCN (propine cyanide), NH3 (ammonia) and various isotopologues of water have been investigated with the goal of obtaining precise transition frequencies in the millimeter- and submillimeter range with accuracies $\leq$ 1 kHz for investigation of the dynamics of interstellar clouds.

Personnel

Head of the group: Prof. Dr.-Ing. R. Knöchel; Secretary: M. Bork
Technical Staff: Dipl.-Ing. (FH) W. Taute

Scientific Staff:

M.Sc. C.-C. Chao	01.01.-31.12.2010	externally funded
Through wall radar		
Dr.-Ing. F. Daschner	01.01.-31.12.2010	CAU
Resonant stents / Microwave sensors / Heterotopic bone induction		
Dipl.-Ing. W. Gerhard	01.01.-31.12.2010	externally funded
High efficiency amplifiers		
Dipl.-Ing. F. Hettstedt	01.01.-31.12.2010	DFG
Magnetic nanocomposites for RF-applications		
Dipl.-Ing. R. Jahns	01.01.-31.12.2010	DFG
Magnetoelectric sensors		
Dr.-Ing. T. Lehmann	01.01.-31.12.2010	CAU
High efficiency amplifiers		
Dipl.-Ing. H. Mextorf	01.01.-31.12.2010	DFG
Non-contacting characterisation of irregular shaped objects		
M.Sc. N. Nasresfahani	01.01.-31.12.2010	DAAD
Metamaterials in microwave structures		
M.Sc. P. Rezaee	01.01.-31.12.2010	DAAD
Microwave filter design with fuzzy logic		

M.Sc. O. Teplyuk 01.01.-31.12.2010 CAU
Radar-sensor

Lectures, Seminars, and Laboratory Course Offers

Winter 2009/2010

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Nichtlineare Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ T. Lehmann)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Summer 2010

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Hochfrequenzschaltungen für Mobil- und Satellitenfunk, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ T. Lehmann)

Rauschen in Kommunikations- und Messsystemen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann, H. Mextorf)

Seminar Hochfrequenztechnik, 1 hrs Seminar/Week,
R. Knöchel

Winter 2010/2011

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Nichtlineare Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Third-Party Funds

Deutsche Forschungsgemeinschaft, *Magnetic nanocomposites for rf applications in mobile communication (Folgeprojekt)*, 01.10.2008-31.01.2011 (91400 EUR)

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm)*, 01.10.2008-31.01.2011 (122300 EUR)

Deutsche Forschungsgemeinschaft, *Aufbau und Optimierung von Spektrometern für den Submillimeterwellen-Bereich sowie Fortsetzung der rotationsspektroskopischen Messungen an interstellaren Spezies*, 01.10.2008-31.03.2011 (53995 EUR)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine*, 01.09.2010-31.08.2011 (7280 EUR)

Innovationsstiftung Schleswig-Holstein, *''lüttIng.'' - Schüler-Technik- Akademie*, 25.05.2010-22.08.2012 (26140 EUR)

Bundesministerium für Wirtschaft und Technologie, *Verbundprojekt: PITAS - Piraterie und Terrorabwehr auf Seeschiffen; Sensorik und Tracking*, 01.07.2010-30.06.2013 (1029711 EUR)

Deutsche Forschungsgemeinschaft, *Sonderforschungsbereich 855, Subproject C3: Sensor Modelling and Electronic Signal Processing*, 01.01.2010-31.12.2013 (579100 EUR)

Further Cooperation, Consulting, and Technology Transfer

There is close cooperation concerning ''magnetic nano composites'' for rf applications with the chairs of ''Multicomponent materials'' (Prof. Faupel) and ''Inorganic functional materials'' (Prof. Quandt) in the **Faculty of Engineering of CAU**.

With the ''Inorganic functional materials'' department (Prof. Quandt) there is also cooperation with regard to ''magnetoelectric sensors''.

There exists a cooperation concerning radiophysics and radioelectronics, radar technology and biological effects of elektromagnetic waves and fields with the **Kharkov National University (KNU)**, Kharkov, Ukraine, in association with research institutes of the Ukrainian academy of science and the ''Institute of Radiophysics (IRE)'', Prof. Shchegoleva and Prof. Khlopov respectively, and the ''Institute of Radioastronomy (IRA)'', Prof. Vavriv. There is also some cooperation within the framework of the Leonard Euler Program of the German Academic Exchange Service (DAAD).

With the **Technische Universität Hamburg Harburg**, Prof. Dr. A. Jacob, we cooperate in the areas of ''microwave components'', ''microwave measurements'' and ''radar technology''.

With Prof. Dr. K. Schünemann, **Technische Universität Hamburg Harburg** and Prof. G. Khlopov, **Institute of Radiophysics**, Kharkov, Ukraine we cooperate in the area of industrial radar sensors.

Concerning sub-millimeter spectrometers and molecular spektroscopy we work in cooperation with the **Applied Physics Institute** of the **Russian Academy of Science** (Dr. Gera Golubjatnikov and Dr. Vladimir Markov) .

Cooperations with industry include; **AMS - Advanced Microwave Systems**, Hamburg, in the area of microwave sensors for density and moisture determination of materials,

Thales, Kiel, in the area of antennas,

Baker Hughes INTEQ GmbH, Celle in the area of high frequency sensors.

A cooperation concerning resonant stents and other stent solutions is carried out together with the **pediatric cardiology clinical center of the Christian-Albrechts-University (PD Dr. Rickers)** and the measurements regarding heterotopic bone inductions are carried out together with the **Department of Oral and Maxillofacial Surgery of the Clinical Center of the Christian-Albrechts-University (PD Dr. Dr. Becker)**.

Diploma, Bachelor and Master Theses

W. Stellmach, *Entwicklung von Baluns mit magnetischen Nanokomposit-Kernen,* 03.02.2010
P. Schluchter, *UWB Antennensystem zur kontaktlosen Materialcharakteristik,* 18.02.2010
L. K. Jensen, *Entwicklung eines Sensors zur berührungslosen und zerstörungsfreien Bestimmung von Materialeigenschaften,* 19.05.2010
R. El Korch, *Streufeldresonator zur Permittivitätsmessung im Mikrowellenbereich,* 02.06.2010
G. Zhao, *Zweimodiger Mikrowellenresonator zur Materialcharakteristik,* 23.08.2010
F. Marx, *Kompakte magnetoelektrische Sensoren zur Messung biomagnetischer Felder,* 15.09.2010
S. Wang, *Hochfrequenzsensor zur Beobachtung einer heterotopen Knocheninduktion,* 10.12.2010
F. Menke, *Detektion von Fremdkörpern mit elektronisch schwenkbarem Antennensystem,* 17.12.2010

Dissertations / Postdoctoral Lecture Qualifications

T. Lehmann, *Sequenzielle Verstärkerarchitekturen für effiziente Leistungsendstufen,* 28.07.2010

Publications

Published in 2010

R. Knöchel, R. Jahns, W. Taute, C. Döscher, *A resonator-based moisture meter for high moisture levels,* Aquametry 2010, 53 - 62 (2010)
F. Daschner, R. Knöchel, *Antennas with Slant Radiation Characteristics for Contactless Material Characterisation at 24GHz,* Aquametry 2010, 90 - 98 (2010)
H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Non-contacting UWB-characterization of dielectric objects using multivariate calibration,* Aquametry 2010, 136 - 144 (2010)
A. Guarnieri, J. Demaison, H.D. Rudolph, *Structure of Ketene - Revisited re (equilibrium) and rm (mass-dependent) structures,* Journal of Molecular Structure, **969**, 1 - 8 (2010)
F. Daschner, *Breitbandige dielektrische Spektroskopie im Mikrowellenbereich,* Proceedings of the 15th Heiligenstädter Kolloquium, 57 - 65 (2010)
F. Hettstedt, U. Schürmann, R. Knöchel, E. Quandt, *Toroid Microinductors Using Segmented Magnetic Cores,* Proceedingsof the International Microwave Symposium 2010, 1348 - 1351 (2010)
H. Mextorf, R. Martens, F. Daschner, R. Knöchel, *Dual polarized UWB antenna for free-space characterization of dielectric objects,* Proceedings of the German Microwave Conference 2010, 162 - 165 (2010)
J. Adam, L. Klinkenbusch, H. Mextorf, R. Knöchel, *Numerical Multipole Analysis of Ultra Wide-Band Antennas,* IEEE Transactions on Antennas and Propagation, **58**, 3847 - 3855 (2010)
H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Free-space determination of permittivity, size and orientation of rectangular shaped objects using multivariate analysis,* Proceedings of the European Microwave Conference, 152 - 155 (2010)
H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *UWB free-space characterization and shape recognition of dielectric objects using statistical methods,* IEEE Transactions on Instrumentation and Measurement, **59**, **12**, 1 - 8 (2010)
T. Lehmann, R. Knöchel, *Signal Pre-Distortion and Bandwidth Requirements for Sequential Power Amplifiers,* Proceedingsof the International Microwave Symposium 2010, 1056 - 1059 (2010)
P. Rezaee, Nasrin Nasr Esfahani, R. Knöchel, M. Tayarani, *Active Learning Method for Microstrip Filter Design,* Proceedings of the 40th European Microwave Conference, 369 - 372 (2010)

Presentations

H. Mextorf, R. Knöchel, *Kontaktlose Charakterisierung dielektrischer Objekte mittels multivariater Analysemethoden,* UKoLoS-Berichtskolloquium, Ulm, Germany, 22.-23.03.2010

Further Activities and Events

Prof. Knöchel served as Dean of the Faculty of Engineering (Technische Fakultät).

Prof. Knöchel is active in the IEEE-MTT (Microwave Theory and Techniques) Society. He was chairman of subcommittee-29 ''Broadband Microwave Systems'' within the programme committee of the ''International Microwave Symposium'', IMS, which is the biggest conference worldwide in that area. He is also, since 2007, a member of the selection committee for the ''IEEE MTT Distinguished Microwave Lecturers'' and Vice-Chairman of the technical committee MTT-16, ''Microwave Systems''. In the ''Technical Coordination Committee (TCC)'' of the MTT society he was responsible for ''European Liaison''. He also represents the MTT in the executive committee of the ''International Conference on Ultra-Wideband, ICUWB''. He is member of the ''editorial board'' of ''Frequenz'' and reviewer for the journals ''IEEE Transactions on Microwave Theory and Techniques'', ''IEEE Microwave and Wireless Components Letters'' as well as journals of the UK ''Institute of Physics'' (IOP) and other journals. He is also member of VDE Expert Group 7.3, ''Mikrowellentechnik''. Prof. Knöchel was also a member of the selection committee ''MENA'' of the German Academic Exchange Service for students from North Africa and Near East. He also has been a member of the prize committee of the ''Schmidt-Römhild-Technologiepreis'' of Schleswig-Holstein for many years. Apart from his membership of the IEEE he is also a member of the ''European Microwave Association, EuMA'' and of URSI, commission A.

Prof. A. Guarnieri, is working in the microwave laboratory and leading the ''molecular spectroscopy''.

Awards: Dipl.-Ing. Robert Jahns received the 2010 Petersen-Award of the Petersen-Foundation for the best Diploma-thesis entitled ''Magnetoelektrische Sensoren für medizinische Anwendungen''.

Dipl-Ing Henning Mextorf received the 3rd place in the 2010 MTT-S IMS ASH Receiver Student Design Competition.