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 recognized research has been carried out during the last decades, has been further extended to field based sensors, which include e.g. eddy current sensors, low frequency capacitive sensors or magnetoelectric sensors. Another working area is **molecular spectroscopy**, where work on spectrometer construction is going on.

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. Special knowledge exists in the application of dielectric spectroscopy and multivariate statistics to the response of the 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 our laboratory. Present work concentrates on special power combiners and also PA linearization.

Industrial microwave sensors is an area, where the microwave laboratory has long lasting experience. A wide range of sensors have been created in the past. Present work concentrates on millimeter wave doppler radar sensors for the characterization of e.g. 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 reading out such devices.

The working area **Materials and high frequency components** is focused on various characterization methods for the determination of the permeabilty of magnetic nanocomposites up to several GHz. The materials are then applied to components like 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 DFG-project ISOPerm (irregular shaped objects permittivity) aims at the development of 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 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 characterisation. Existing methods for such measurements require that the samples are regular in shape. It is also necessary that the entire cross section of the used electromagnetic field is filled with the material under test. The investigated and developed method does not require these restrictions. Contrary to existing methods and as a novel approach an attempt was made to use multivariate analysis to separate those effects caused by the geometry of the object from those caused by its dielectric properties. It was successfully proved with simulations and measurements of dielectric objects and the usage of multivariate analysis methods that the determination of the dielectric properties is possible independently of shape, size and orientation to a certain accuracy. An UWB measurement system consisting of one transmitting antenna and an array of receive antennas was built. This array receives scattered pulses of the illuminated object under test in two orthogonal polarizations. Further investigations will focus on the development of a stand-alone sensor system capable of working in real time. This will reveal the system performance and accuracy under practical

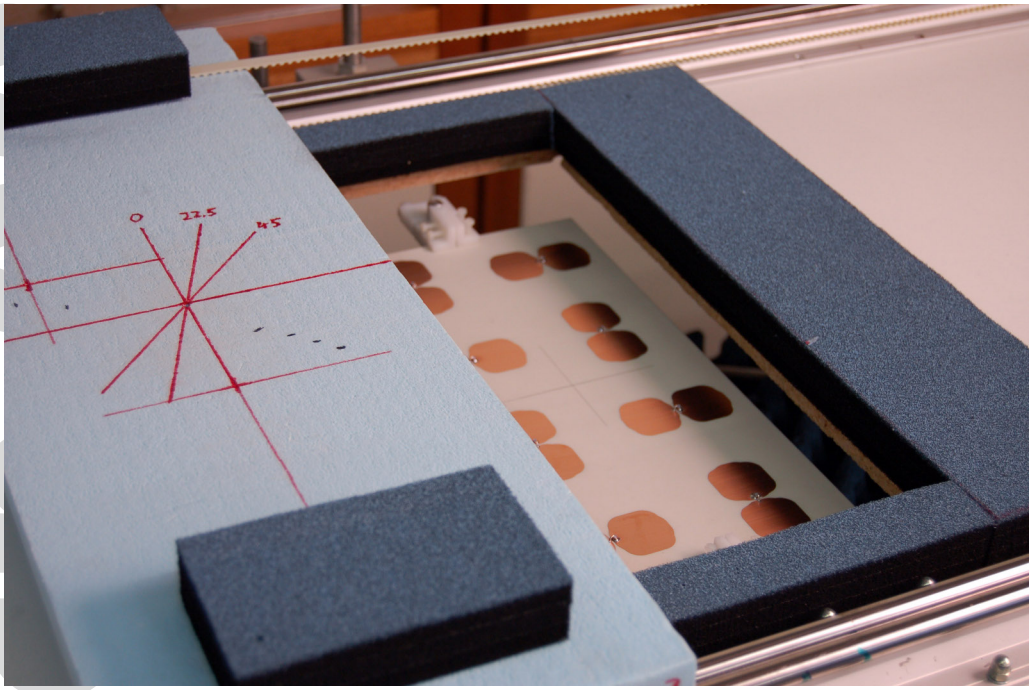

Fig. 1: Antenna array for the characterization of irregularly shaped dielectric objects by UWB signals with orthogonal polarizations

conditions. The system will be tested with unknown objects of irregular shape. It will be also investigated whether it is possible to find relevant classes of objects in practice in order to build specialized systems to be devised with greatly reduced hardware effort but increased accuracy.

Radar-sensor

As a continuation of the remote sensing study of aerosols with small particle sizes (dust, rain, fog. etc.), a two frequency millimetre wave Doppler radar system was constructed on the basis of the previously developed radars with operating frequencies of 35 GHz and 94 GHz. One of the problems of aerosol sensing by Doppler radar using only one operation frequency is the impossibility of the determination of characteristics for existing aerosols without any calibration procedure. Due to high complexity these calibration procedures cannot be carried out frequently under real conditions. Therefore, an attempt to develop a data processing method which can avoid the calibration was made. This method is based on the combination of spectral analysis and Mie theory (the analytical solution of the dielectric sphere diffraction problem), since the aerosol particle size is essentially smaller than the operating wavelength and since it can be assumed that the shape of the particles is spherical. Therefore, radar cross section dependencies on particle size are different for each wavelength. This permits to estimate the physical characteristics (such as parameters of particle size distribution, mass loading and particle concentration) of polydisperse mediums with different particle size distribution laws. The method was tested with calibrated experimental powder with log-normal particle size distribution law and satisfactory results were obtained: the calculated and measured data discrepancy is less than 10% for mass loading determination, and about 25 % for particle concentration determination.

Radar Antennas & Systems

A high performance radar antenna array (X-band) prototype with low side lobe levels was designed and practically built. The strong coupling of adjacent radiating elements was taken into account. The overall design was verified by full wave simulations. The antenna was measured and characterized by indoor near- and outdoor far-field measurements showing excellent performance and an over-fulfilling of the electrical performance requirements in terms of gain, beamwidth, side

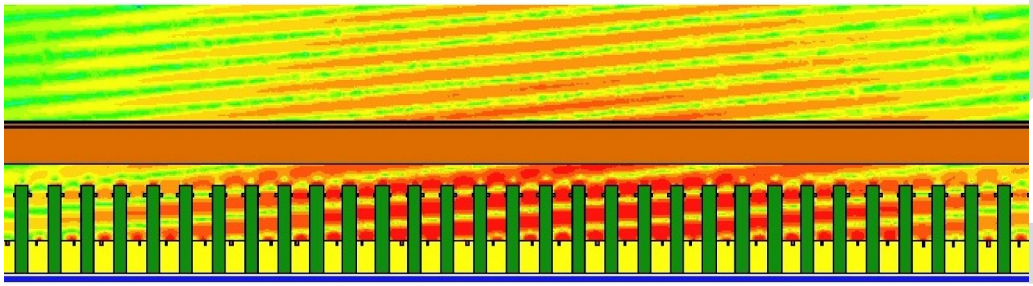

Fig. 2: Full wave simulation of a high performance radar antenna array. The slightly tilted phase fronts of the emitted wave can clearly be seen.

lobes, VSWR and bandwidth. Furthermore we counselled in the design of improved radar systems and components.

Magnetoelectric sensors

New magnetoelectric (ME) sensors will be developed in collaboration with the Multicomponent Materials Chair of CAU Kiel in order to measure weak biomagnetic fields in the region of 1 pT and below. A new readout electronic will be created, which is matched to the sensor. In a first step equivalent circuits of different ME sensors were modelled. Measurements have shown that these equivalent circuits are capable to describe the ME sensor in resonance. In order to perform ME sensor measurements, it was necessary to establish a measurement setup. The core of this setup are two pairs of Helmholtz coils, which generate a DC magnetic field to investigate the optimal working point and an AC magnetic field to investigate linearity and resonance of different ME sensors. Furthermore the noise behaviour of the whole detection unit is under investigation, consisting of the ME sensor and the following low noise preamplifier. Due to the modelling of the equivalent circuit, we are able to calculate the broadband noise behaviour of the ME sensor. In order to improve the signal to noise ratio of the detection unit, low noise preamplifiers are investigated which are suitable for this new kind of magnetic field sensor. Noise measurements are performed, to evaluate the noise calculations for sensor and preamplifier.

Wireless flow rate measurement in vascular implants

For some inborn heart abnormities surgically corrections are possible in order to enable a survive of the patient. For example the hypoplastic left heart syndrome can be treated by several sequential operations. Between these operations the usage of vascular implants is necessary for some months. The vascular implants are made from plastics and not from tissue of the own body. Therefore there is a relatively high risk for a stenosis by fibrin.

In order to prevent this life-threatening complication a periodic monitoring of the flow rate in the vascular implant is obligatory. The usage of imaging methods based on X-rays has the disadvantage that the patients will get high radiation dosages. This is especially critical for infants. Since the vascular implants are only within the body for a relative short time theoretically it is possible to include a flow rate sensor within the vascular implant. The electronics can be fed by a small battery and the sensor transmits the information about the flow rate to the reading device outside the body using electromagnetic fields. Hence the important information is immediately available whenever it is needed without stress for

the body.

Beside the RF-electronic there is a need for the actual flow rate sensor. The used method should work without a direct contact to the blood because foreign substances provokes stenosises. In this project capacitive designs and methods based on the Lorentz-force have been investigated together with the pediatric cardiology clinical center of the Christian-Albrechts University. The work has been started in 2009 and first encouraging results were worked out.

Magnetic Nanocomposites for RF-Applications

In cooperation with the Multicomponent Materials and the Inorganic Functional Materials chair novel magnetic materials are developed and novel devices using these materials are investigated. Analytical expressions for the properties of these materials are found and the materials are characterized by measurements. On the other hand the measured permeability spectrum is used to calculate unknown materials parameters using nonlinear regression algorithms.

Furthermore a new approach to toroid microinductors with magnetic core was introduced. The core consists of a segmented metal-polymer composite. The investigations aim at fulfilling the demands of small size, high inductance, high operation frequency, and adequate quality factor required for modern mobile communication electronics. A torodial inductor was designed using HFSS and realized in thin-film technology with various core designs to avoid eddy currents and minimize parasitic capacitances. The magnetic core is formed by a segmented multilayer of sputter deposited soft magnetic FeCoBSi, which was deposited in a special way to realize a crossed anisotropy.

Sequential Power Amplifiers

Ordinary power amplifiers achive maximum effciency only at maximum output power levels. If the output power is reduced effciency decreases dramatically. Due to the properties of the modulated signals (peak to average ratios of 5-10 dB), average efficiencies of only 10% and lower are achieved under linear amplification. Therefore effciency enhancement is strongly required.

The Sequential Power Amplifiers (SPA) concept is investigated as a new method to enhance the efficiency of ordinary amplifiers driven with digitally modulated signals. In its simplest form a SPA consist of two ordinary amplifiers combined in parallel with a conventional directional coupler. For low power only one amplifier is operating while the second amplifier is switched off and energy is saved. At high power levels both amplifiers contribute rf power to the output. Therefore the avarage effciency of the whole system compared to an equivalent single amplifier is significantly improved due to the turned off pheriphery in lower power region. SPAs achieve about 50% of average effciency for a WDCMA signal, where the ordinary amplifier achieves only 37%.

In 2009 investigations were focused on the bandwidth requirements for the required signal pre-distortion. The signal construction for the individual amplifiers causes a bandwidth widening and therefore a bandwidth restriction is necessary. The reduced bandwidth influences also the system effciency, which results in a bandwidth dependence of the SPA effciency.

Efficiency and Linearity enhancement of outphasing power amplifiers

Further research is ongoing on the field of efficient and linearly operating outphasing power amplifiers. A novel compact outphasing combiner was proposed and developed. Its operation and design application was mathematically described. Design trade offs are carried out. A practical validation was performed by simulation and measurements. Further research interest is the analytical analysis of the impact of the transistors load line modulation to the obtainable linearity.

Digital dynamic predistortion linearization of high power short wave (1.5-30MHz) power amplifiers

The strong static and dynamic (memory effects) distortions of a broadband short wave frequency high power (150W) amplifier were investigated by practical measurements. Two tone and QPSK signals were applied for tests. Potentially electrical and temporal sources of memory distortions especially occurring with signals with increased bandwidth were applied. Recommendations to improve the electrical PA design were carried out. A digital predistortion algorithm was

developed and applied to the PA capable also to compensate dynamical memory effects. The intermodulation distortions of a broadband two tone signal could be improved by more than 20dB. This demonstrates the superior performance of the applied dynamical predistortion algorithm. Furthermore a practical TX/RX system based on a FPGA-core utilizing a polynomial memory architecture was investigated and proposed.

Molecular Spectroscopy

The molecular spectroscopy in the range of millimeter- and submillimeter wavelengths (carried out by Prof. Guarnieri) allows the investigation of free molecules in the gasphase. In this state the molecules are in a continous motion proportional to their thermal energy. A part of this energy is stored as rotational energy. The activity of the lab was concentrated to the improvement of the resolution property of the millimeter- and submillimeter wave spectrometer for allowing 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. The labspectra of such molecules in the millimeter- and submillimeter range measured with a precision $\leq$ 1 kHz are therefore requested for astrophysical investigations today. To this purpose the local spectrometer has been supplemented with devices which have allowed to take up absorption lines with lamb-dip accuracy. This method allows the measurement of the absorption lines with a precision $\leq$ 1 kHz. A corresponding paper has been published 2007 in Astrophysics Letters. Within the scope of the DFG-cooperation project (official ending end of 2010) 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.

Fig. 3: Visit at RFS, Hannover

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.-31.12.2009	fremd
UWB-Innenraumradar		
Dr.-Ing. F. Daschner	01.01.-31.12.2009	CAU
Resonante Stents / Mikrowellensensoren für dielektrische Eigenschaften / Miniaturisierter Netzwerkanalysator		
Dipl.-Ing. W. Gerhard	01.01.-31.12.2009	fremd
Verstärker mit hohem Wirkungsgrad		
Dipl.-Ing. F. Hettstedt	01.01.-31.12.2009	DFG / CAU
Induktoren mit magnetischen Nanocompositen		
Dipl.-Ing. R. Jahns	01.-31.12.2009	CAU
Magnetoelektrische Sensoren		
Dipl.-Ing. T. Lehmann	01.01.-31.12.2009	CAU
Wirkungsgradverbesserung von Leistungsverstärkern		
Dipl.-Ing. H. Mextorf	01.01.-31.12.2009	CAU / DFG
Kontaktlose Charakterisierung unregelmäßig geformter Objekte		
M.Sc. N. Nasresfahani	01.10.-31.12.2009	DAAD
Metamaterialien für Mikrowellen-Resonatoren		
M.Sc. P. Rezaee	01.10.-31.12.2009	DAAD
Mikrowellen-Filter		
M.Sc. O. Teplyuk	01.01.-31.12.2009	fremd / CAU
Messung der Partikeldichte in Aerosolen		

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

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

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

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

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 2009

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

Hochfrequenztschaltungen für Mobil- und Satellitenfunk, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

R. Knöchel (+ H. Mextorf)

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

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

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

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

Third-Party Funds

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine*, 01.09.2008-31.08.2009 (10910 EUR)

Deutsche Forschungsgemeinschaft, *Magnetic nanocomposites for rf applications in mobile communication (Folgeprojekt)*, 01.10.2008-31.03.2010 (91400 EUR)

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm)*, 01.10.2008-30.09.2010 (122300 EUR)

Deutsche Forschungsgemeinschaft, *Aufbau und Optimierung von Spektrometern für den Submillimeterwellen-Bereich sowie Fortsetzung der rotationsspektroskopischen Messungen an interstellaren Spezies*, 01.10.2008-30.09.2010 (53995 EUR)

Further Cooperation, Consulting, and Technology Transfer

With the chairs of „Materialverbunde“ (Prof. Faupel) and „Anorganische Funktionsmaterialien“ (Prof. Quandt) of the **Technische Fakultät der CAU** there is close cooperation concerning „magnetic nano composites“ for rf applications.

With the chair „Anorganische Funktionsmaterialien“ (Prof. Quandt) of the **Technische Fakultät der CAU** there is also cooperation with regard to „magnetoelectric sensors“ .

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, and the „Institute of Radioastronomy (IRA)“ , Prof. Vavriv, there exists a cooperation concerning radiophysics and radioelectronics, radar

technology and biological effects of elektromagnetic waves and fields, as well as in the frame 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 area 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.

With the **Applied Physics Institute** of the **Russian Academy of Science** (Dr. Gera Golubjatnikov and Dr. Vladimir Markov) we cooperate concerning sub-millimeter spectrometers and molecular spektroscopy.

With **AMS - Advanced Microwave Systems**, Hamburg, there is cooperation in the area of microwave sensors for density and moisture determination of materials.

With **Thales**, Kiel, we cooperate in the area of antennas.

With **NXP Semiconductors**, Nijmegen, Holland, exists a cooperation regarding microwave power amplifiers.

With **Baker Hughes INTEQ GmbH**, Celle there exists cooperation 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)**.

Diploma, Bachelor and Master Theses

T. Huang, *Ultra-Breitband Antennensystem bei 24 GHz*, 12.01.2009
R. Martens, *Entwicklung und Aufbau dual polarisierter UWB-Antennen*, 05.06.2009
M. Weinrich, *Aufbau und Untersuchung eines Doherty-Verstärkers*, 11.06.2009
S. Hoffmann, *Entwicklung eines resonanten Stents zur drahtlosen, nicht invasiven Messung von Stenosen*, 16.06.2009
J.-Ch. Heck, *Antennen-Array mit einstellbarer Richtcharakteristik*, 20.07.2009
D. Schaper, *Nicht invasive Durchflussmessung in Stents basierend auf dem Hall-Effekt*, 24.09.2009
R. Jahns, *Magnetoelektrische Sensoren für medizinische Anwendungen*, 06.11.2009
J.-H. Dornberg, *Analyse effizienter Verstärkermethoden: Der Doherty-Transmitter*, 13.11.2009
Q. Zhong, *Entwicklung und Untersuchung eines Mikrowellensensors zur Permittivitätsmessung*, 16.11.2009

Publications

Published in 2009

T. Lehmann, F. Hettstedt, R. Knöchel, *Reconfigurable Wilkinson Power Dividers with Minimum Number of Switches*, Electronics Letters, **45, Issue 2**, 111 - 112 (2009)

F. Hettstedt, T. Lehmann, R. Knöchel, *Novel Dual Mode Microstrip Bandpass-Filter*, Microwave Magazine, **10**, 155 - 157 (2009)

T. Lehmann, R. Knöchel, *Power Ampflifier Efficiency Enhancement using Adaptive Load Transformation*, Proceedings of the German Microwave Conference 2009, (2009)

W. Gerhard, R. Knöchel, *Improved Design of Outphasing Power Amplifier Combiners*, Proceedings of the German Microwave Conference 2009, (2009)

F. Hettstedt, U. Schürmann, R. Knöchel, E. Quandt, *Double Coil Permeameter for the Characterization of Magnetic Materials*, Proceedings of the German Microwave Conference 2009, (2009)

T. Lehmann, R. Knöchel, *Sequential Power Amplifiers with Adaptable Combiners*, Proceedings of the International Microwave Symposium 2009, 767 - 770 (2009)

H. Mextorf, T. Lehmann, R. Knöchel, *Systematic Design of Reconfigurable Quadrature Directional Couplers,* Proceedings of the International Microwave Symposium 2009, 1009 - 1012 (2009)
A. Teplyuk, R. Knöchel, G. Khlopov, *Aerosol Particle Sensor Based on Millimeter-Wave Coherent Radar with High Spatial Resolution,* Proceedings of the International Microwave Symposium 2009, 1173 - 1176 (2009)
T. Lehmann, R. Knöchel, *Design and Performance of Multi-Channel Switched Sequential Amplifiers,* International Journal of Microwave and Wireless Technologies, **1**, **Special Issue 4**, 269 - 275 (2009)
U. Schürmann, A. Gerber, F. Hettstedt, V. Zaporojtchenko, R. Knöchel, F. Faupel, E. Quandt, *Fabrication of Toroidal Microinductors for RF Applications,* IEEE Transactions on Magnetics, **45**, **Issue 10**, 4770 - 4772 (2009)
R. Knöchel, G. Khlopov, A. Linkova, A. Teplyuk, K. Schünemann, O. Vojtovych, *Double Frequency Sounding of Volume Scatterers,* Proceedings of the International Radar Symposium 2009, 437 - 441 (2009)
I.M. Tiginyanu, E. Foca, V.V. Sergentu, V.V. Ursaki, F. Daschner, R. Knöchel, H. Föll, *Design and Characterization of Novel Focussing Elements Based on Photonic Metamaterials,* Journal of Nanoelectronics and Optoelectronics, **4**, **no. 1**, 20 - 39 (2009)
F. Daschner, R. Knöchel, *Dual operation mode resonator with fractal structure for the dertermination of the conductivity and permittivity of materials,* Proceedings of the 8th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, (2009)
M. Kent, F. Daschner, *Time domain spectroscopy, Fishery products: quality, safety and authenticity,* 273 - 285 (2009)

Presentations

H. Mextorf, R. Knöchel, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte,* UKoLoS Berichtskolloquium, Erlangen, Germany, 26.-27.02.2009
F. Hettstedt, U. Schürmann, R. Knöchel, E. Quandt, *Double Coil Permeameter for the Characterization of Magnetic Material,* German Microwave Conference, München, Germany, 16.-18.03.2009
T. Lehmann, R. Knöchel, *Power Amplifier Efficiency Enhancement using Adaptive Load Transformation,* German Microwave Conference, München, Germany, 16.-18.03.2009
W. Gerhard, R. Knöchel, *Improved Design of Outphasing Power Amplifier Combiners,* German Microwave Conference, München, Germany, 16.-18.03.2009
F. Daschner, R. Knöchel, *Dual operation mode resonator with fractal structure for the determination of the conductivity and permittivity of materials,* 8th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances (ISEMA 2009), Helsinki, Finland, 01.-03.06.2009
T. Lehmann, R. Knöchel, *Sequential Power Amplifier with Adaptable Combiners,* International Microwave Symposium, Boston, USA, 07.-12.06.2009
H. Mextorf, T. Lehmann, R. Knöchel, *Systematic Design of Reconfigurable Quadrature Directional Couplers,* International Microwave Symposium, Boston, USA, 07.-12.06.2009
A. Teplyuk, R. Knöchel, G. Khlopov, *Aerosol Particle Sensor Based on Millimeter-Wave Coherent Radar with High Spatial Resolution,* International Microwave Symposium, Boston, USA, 07.-12.06.2009
A. Teplyuk, R. Knöchel, G. Khlopov, *94-GHz Industrial Radar Sensor for the Quantitative Monitoring of Dust Particles and Aerosols,* New Component Technologies for Vehicular and Industrial Radar Applications Workshop, International Microwave Symposium, Boston, USA, 07.-12.06.2009
R. Knöchel, G. Khlopov, A. Linkova, A. Teplyuk, K. Schünemann, *Double Frequency Sounding of Volume Scatterers,* International Radar Symposium, Hamburg, Germany, 09.-11.09.2009
H. Mextorf, F. Daschner, R. Knöchel, *Drahtlose Erkennung dielektrischer Objekte unregelmäßiger Form mittels UWB-Pulsen,* Kleinheubacher Tagung, Miltenberg, Germany, 28.09.-01.10.2009
F. Hettstedt, H. Mextorf, R. Knöchel, *HF-Charakterisierung weichmagnetischer Materialen,* Kleinheubacher Tagung, Miltenberg, Germany, 28.09.-01.10.2009

Further Activities and Events

Prof. Knöchel served as Vice-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 subcommitte-29 „Broadband Microwave Systems" within the program committe of the „International Microwave Symposium" , IMS, which is the biggest conference worldwide in that area. He is also since 2007 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 English „Institute of Physics" (IOP) and other journals. He is also member of VDE Expert Group 7.3, „Mikrowellentechnik" . Prof. Knöchel was also member in the selection committee „MENA" for students from North Africa and Near East of the German Academic Exchange Service. He is also member in the prize committee of the „Schmidt-Römhild-Technologiepreis" of Schleswig-Holstein for many years. Apart of the membership in the IEEE he is member of the „European Microwave Association, EuMA" and member of URSI, commission A.

The microwave group has participated in the project-week mobile communications and in the „Schüler Technik AG" , where FM Radio receivers were built up. Work was done by **Dipl.-Ing. T. Lehmann**.

Two student excursions have been made: The first in February 2009 visited Raytheon Anschütz in Kiel. Twenty students an rf staff participated. The second took place in June. RFS (Radio Frequency Systems) was visited with fivteen students and rf staff. Dipl.-Ing. Thomas Lehmann has devoted much work to these excursions.

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

Awards: Dipl. wirtsch.-Ing. Steffen Hoffmann received the 2009 Petersen-Award of the Petersen-Foundation for the best Diploma-thesis entitled „Entwicklung eines resonanten Stents zur drahtlosen nicht invasiven Messung von Stenosen" .