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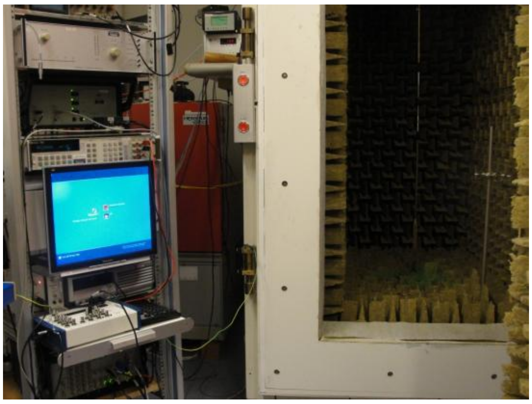

Novel primary calibration setup for quarter inch microphones up to 150 kHz.

Welcome

This is the second newsletter of the project "Metrology for a universal ear simulator and the perception of non-audible sound", and again I welcome you as a person interested in our work. We are pleased to say that our project has started successfully and the first results are ready to be presented to all potential users and those with a general interest.

In first months the project has focused on establishing of the technical basis for the investigations in the work packages. For magnetoencephalography (MEG) a new phantom was designed and manufactured. The metrological basis of sound measurement was significantly improved by the world's first primary microphone calibration system extending up to 150 kHz, providing traceability for airborne sound at ultrasound frequencies. The development of a universal ear simulator started with defining specifications and a summary of data available for the description of properties for a ear simulator.

I hope you will find valuable information in the newsletter. We are interested to keep in contact with you as stakeholders, users, or interested persons and we are looking forward welcoming you in our project community.

Christian Koch
Coordinator

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News and facts

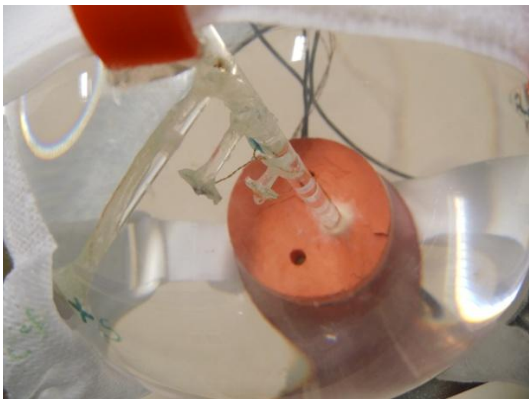
- The project team was strengthened by a research excellence grant: Since 1 September 2012 Dr. Torsten Marquardt from the Ear Institute at University College London, UK is part of the project team.
- The number of collaborators has increased: The Institute of Acoustics of RWTH Aachen, Germany joined the project (contact: Dr. Janina Fels).
- The next project meeting will take place in Copenhagen (DK) on 16/17 April 2013. Collaborators are invited to join at the second day of the meeting.

Highlights from the work packages

New MEG phantom

To evaluate methods and measurement systems, a MEG head phantom was constructed from a sphere filled with a saline solution. We chose to simulate four auditory processing centres along the auditory pathway: The auditory cortex and three centres in brainstem. Four electrode pairs can simulate four compound magnetic dipoles, one for each processing centre. The conducting fluid closes the electric circuit to mimic a volume conductor as it is the brain.

The principal of operation is as follows. A current flowing through two opposing electrodes results in a magnetic moment and generates a magnetic field. In this way we activate the artificial centres of hearing, measure the magnetic field, and then test new methods for the reconstruction of these centres from the measured data.



View into the fluid filled sphere filled with electrode pairs.

Primary calibration of microphones up to 150 kHz

The investigation of the perception mechanisms of ultrasound requires that the sound sources used in the tests are well characterised and traceable throughout the frequency range of interest. Setting up a well-defined traceability chain starts with a realisation of the unit for sound in air, the Pascal, via the calibration of measurement microphones in the frequency range of interest (up to at least 80 kHz).

Most measurement microphones can be calibrated in a free field at frequencies up to 50 kHz. Although this is more than sufficient for most sound measurement applications related with noise assessment, this frequency range does not cover the application at hand. In order to extend the frequency range of free-field calibration, previously existing measurement system and measurement methods must undergo a series of changes and adaptations including the type of measurement signal, methods for eliminating unwanted reflections from walls, cross-talk, etc.

A measurement system and a calculation procedure that allow for the determination of the free-field sensitivity of working standard

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microphones (IEC type WS3) at frequencies up to 150 kHz have been developed. The microphones calibrated in this system will be used to characterise the sound sources used in the investigation of the perception of ultrasound. Further refinements of the system and the calculation procedures are underway.

Non-magnetic ultrasound source using MEMS technology

To provide the stimulus for evaluating the perception threshold to ultrasound, an in-ear airborne ultrasound transmitter and sound pressure level (SPL) monitoring system is being developed. The transducer will transmit high-frequency (10 kHz to 80 kHz) sound directly into a subject's ear canal, whilst their brain activity is imaged with MEG or fMRI to look for evidence of spontaneous perception. The transmitter needs to be capable of delivering a sufficiently high SPL to the ear canal, and be constructed entirely of nonmagnetic materials so that it can be used within MEG and fMRI environments without causing artefacts in the images. The SPL produced will need to be monitored in real time by a small, non-magnetic microphone also within the ear canal.

The transmitter and monitoring system are being developed using silicon micro-electro-mechanical systems (MEMS) technology. The proposed devices use a MEMS structure that can be configured to be either a transmitter or receiver to produce the nonmagnetic transducer. A 3D-printed waveguide has been developed that couples the output of four transmitting transducers (for increased SPL) into the ear canal, whilst simultaneously supporting a fifth transducer acting as microphone within the ear canal. A double-size model of the system is shown in the figure.

A double-size model of the MEMS system.

Specifications of universal ear simulator

In a process aiming at designing and producing a new prototype *universal ear simulator*, the first task has consisted of establishing its specifications in accordance with user requirements. Thus, the methodology of designing an ear simulator has been tackled to emphasize the key parameters of its design. This involved two parallel activities. First, a detailed study of existing literature have been undertaken, to gather the key physiological parameters relating to ears and hearing for subjects across all age groups from newborns to adults. Second, a questionnaire has been sent to specialists in the field of hearing (both audiologists and researchers) in order to identify their expectations for device universal ear simulator. As a result, it is expected to use principally short term signals in order to mainly calibrate insert earphones but also circum-aural and supra-aural earphones as well as insert probes.

From the literature review, five age groups have been established. The figure below shows the average input impedance associated with the standard deviation (grey areas) for the five groups that cover the following age ranges: neonates (red line), from 1 to 3 months (blue line), from 3 to 24 months (green line), from 2 to 7 years (magenta line), and adults (black line). Following the consultation and

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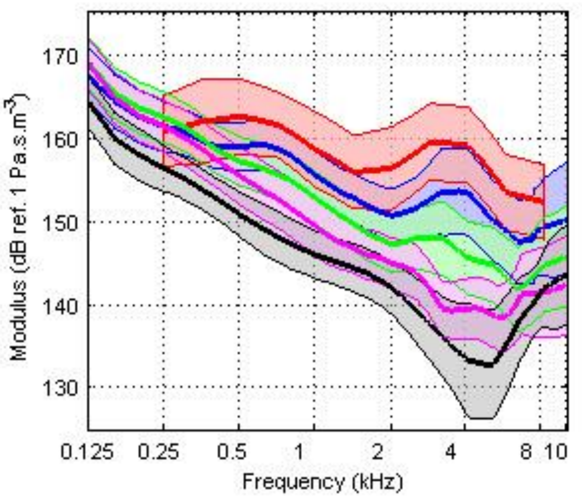
literature the ear simulator specification that be defined currently for the defined age groups is an occluded universal ear simulator for the calibration of insert earphones or insert probes in the frequency range 250 Hz to 8 kHz for the neonates group, and 125 Hz to 10 kHz for the other age groups.



Modulus of the input impedances (solid lines) and standard deviations (grey areas) versus frequency for: neonates (red), 1-3 months group (blue), 3-24 months (green), 2-7 years (pink) and adults (black).

Dissemination of work

One of the cornerstones of the EMRP, is that research projects should *create impact and benefits* for its stakeholders. This section provides a summary of recent dissemination activities.

Project logo

You may have notice at the top of this newsletter that a new logo has been designed to EAR-mark the project. The logo designer has tried to capture as many facets of the project as possible in a distinctive graphic. The simple yet striking logo manages to depict the elements of low frequency and high frequency sound and articulates that the project is about *ears* both in terms of ear simulators and the fact that ears facilitate our perception of sound.

Collaborations

The range of collaborators engaged in the project is growing. Janina Fels, who has recently completed a PhD on age related changes in auditory processes and characteristics, has joined the project as a new collaborator. Further visits or discussions have been held with NALS, the noise and acoustics interest group within DIN, audiologists in Germany, Scandinavia, UK and Turkey in developing user requirements for the *universal ear simulator*, the EAR Institute at University College, London, Otodynamics pioneers in OAE measurements and at Lübeck University.

If you would like to have closer contact with the EARS project team, details of how to reach us can be found below.

Presentations

Various members of the project team have been active in presenting an overview of the project at a number of key metrology and standardization meetings.

Christian Koch presented at EURAMET TC-AUV, the forum for all European national measurement institutes involved in acoustics to discuss and co-ordinate their research.

Salvador Barrera-Figueroa presented at BIPM CCAUV, 13 June 2012, providing the first exposure of the project to the worldwide acoustic metrology community.

Thomas Fedtke presented the ear simulator aspects of the project at IEC TC29 WG21 (Ear Simulators), stating that the project is addressing the long-standing requirement for

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new ear simulators for neonatal applications, already identified as a strategic need in WG21.

Further presentations on the project are planned at some of the key acoustics conferences coming up in 2013, so please look out for us.

Do also check the project website for the latest developments.

http://www.ears-project.eu/emrp/ears.html

Business card of partners: National Physical Laboratory, UK

In this column of every newsletter we will introduce you to one of the institutes of the consortium. Today: National Physical Laboratory (NPL), UK.

NPL is the UK's National Measurement Institute, and a world-leading centre of excellence in developing and applying the most accurate measurement standards, science and technology available. For more than a century NPL has developed and maintained the primary measurement standards that underpin the infrastructure of traceability throughout the UK and the world. Today, NPL's vision is to be a science and technology laboratory for government and business, undertaking work in the national interest, delivering social and economic impact through world-class measurement science, innovative applied research and effective dissemination of knowledge, skills and capabilities.

View on the new reception at entrance of NPL site.

Working across scientific disciplines and industrial sectors, NPL employs a diverse work force and collaborates widely with other NMIs, academia, and with the smallest and the largest commercial and industrial organisations. *Acoustics* is one of over twenty scientific areas covered by NPL's research programmes. The Acoustics Team at NPL includes a group conducting research relating to sound in air. One of their recent successes has been to demonstrate the feasibility of using silicon MEMS microphones in measurement applications. This technology is now being exploited in the EARS project to develop transducers that can be deployed in the harsh electromagnetic environments used in neuroimaging.

The NPL Acoustics Team also has a long association with the development of ear simulators that are used as transfer calibration devices for earphones. Recent achievements include the development of new calibration methods to comprehensively characterise the performance of ear simulator, which will need to be adapted for the universal ear simulator being developed in the EARS project.

Scientific excellence itself does not guarantee that research discoveries create their desired impact or benefits in society. Consequently NPL invests heavily in the dissemination of

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technology and knowledge, working closely with stakeholders and stakeholder networks, using a variety of knowledge transfer mechanism, activities and media. NPL is therefore well-placed to lead the work package dedicated to *creating impact* in the EARS project.

Visit NPL at http://www.npl.co.uk

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You can subscribe to this newsletter on our website.

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