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Brief review of the recent researches in Acoustics, Ultrasound and Vibration at INMETRO

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VIBRATION

During the last two years, the Vibration Laboratory has been involved with the development of a quadrature homodyne interferometric system for the determination of the complex sensitivity of accelerometers. This system was part of a doctorate thesis [1] concluded in March 2005.

This system was presented at the recent AIVELA conference [2], describing the use of digital high-pass filtering to reduce the influence of LF noise for calibrating accelerometers by the sine approximation method. The filter is a recursive moving average type, with a bilateral implementation to allow no phase delay. Numerical simulations of this filter have demonstrated its efficacy. The system includes a dedicated sample clock generator to ensure that the flexible sampling rate is an even number of samples per vibration cycle. This synchronization scheme reduces significantly leakage problems allowing us to discard the use of time windows. In addition, the parallel of measurement data by three signal processing techniques increase the confidence in the obtained results. It is easy to show that voltage and phase results from the SAM, the single-sine correlation method and DFT are identical. This system was used to make the measurements for the comparison SIM.AUV.V-K1.1. Expanded uncertainties with a coverage factor $k = 2$ of ± 0,25 % and ± 0,25° are estimated for modulus and phase shift, respectively, at the reference frequency of 160 Hz [3]. Calibrations are usually performed in the frequency range from 10 Hz to 10 kHz, but measurements have already been made up to 50 kHz.

Small adaptations to this system also allow calibration of laser vibrometers with analog output [4]. Since digital vibrometers are becoming more popular, a new dedicated system will be built to extend our capability to calibrate vibrometers with digital output. This new system is expected to be operational in 2007.

Many investigations were carried out to improve our uncertainty of measurement. The temperature influence on the gain of charge amplifiers was evaluated [5-6] and the many sources of error generated by imperfect shakers were studied [7-8].

Future projects include the development of a calibration shaker and the development of a primary shock calibration system.

ELECTROACOUSTICS

The Electroacoustics Laboratory has been working on the calibration of microphones by the impulse response technique. The application of sine sweeps to obtain optimal impulse responses has been extensively investigated, including sweeps with arbitrary emphasis [9-14]. This subject was object of a doctorate research [15] concluded in September, 2006. The proposed

method was tested at the PTB/Germany demonstrating a very good agreement with the results obtained by the classical comparison approach used by the PTB. An advantage of the new method is that it can be used in any environment while the classical approach requires measurements in an anechoic chamber.

The systems for calibration of sound level meters, octave and fractional-octave band filters and audiometers were improved during the last year [16-20]. These systems were computer automated, decreasing substantially the calibration period and measurement uncertainty.

A system for signal generation in accordance with the new standard IEC 61672 for calibration of sound level meters [17] is under development. In addition, the calibration of reference signal generators was implemented.

The Electroacoustics Laboratory has also developed a THD calibration system using a dc sampling voltmeter Agilent 3458A to acquire distorted signals and measure the distortion parameters of a generated arbitrary waveform. Another research deal with FFT-based distortion measurements using continuously varied excitation signal amplitudes [21].

In 2006, investments are being directed to improve the measurement capability in eletroacoustics. Acquisitions are being made to allow the implementation of a primary microphone calibration system in free-field.

Another important project is the development of a compact measurement front-end to be used in acoustics and vibration [22]. This system incorporates many capabilities, including signal generation, power amplification, microphone and accelerometer power supply and two measuring channels with 24 bits resolution. This hardware will work with the software Monkey Forest and is expected to be used in many applications, like comparison calibration using stepped-sine and the fast swept-sine technique, reverberation time measurements, distortion measurements, etc.

A large effort was dispended by the acoustics technical staff on the development of national standards based on the IEC and ISO standards and on technical assessments for the accreditation of secondary laboratories.

ACOUSTICS TESTING

The Acoustics Testing Laboratory has been applying the impulse response technique to many acoustical measurements. The application of sine sweeps with arbitrary emphasis to obtain improved impulse responses has shown several advantages compared to classical methods [23-24]. This technique can be used in many applications in the field of building acoustics, like sound insulation and reverberation time measurements [25-28].

One of the main research interests of the Acoustics Testing Laboratory has been sound absorption [29-35]. Absorption measurements in reverberant rooms have been subject of many publications. A portable apparatus was developed and has been used with the pulse reflection technique to allow *in-situ* measurements of sound absorption coefficients. The most recent interest in this field has been the improvement of the measurement uncertainty estimation.

A research project focused the evaluation of sound quality in local schools. Word intelligibility tests have been performed and technical advice was furnished to the local state authorities to help improving the quality of existing classrooms [36].

Another important research line is sound power measurement. The development and qualification of sound sources has been the subject of some studies [37] and the laboratory played a very important role in the development of the Brazilian Noise Labeling Program. Through the dissemination of sound power emission values via appliances like blenders, hair dryers, etc., it was intended to spread the metrological culture to the population. This program required the development and standardization of measuring methods for different appliances [38-40] and accreditation of secondary laboratories to perform measurements in a large scale.

ULTRASOUND

The project of implementing an Ultrasound Laboratory began in 2003. A first researcher started a doctorate in ultrasound and attended a training program which included an 8 month period as guest researcher at the ultrasound laboratory of the NPL/UK. This doctorate was concluded in 2005 [41] and after this other researchers joined INMETRO.

At present, the Ultrasound Laboratory has three researchers dedicated to the development of the calibration and measuring systems. Initially a force radiation balance and an acoustic pressure field mapping system will be implemented.

Many publications were produced in this short period [41-62]. The first studies were carried out using the facilities of the biomedical engineering program of the Federal University of Rio de Janeiro. The main research subjects have been studies of feasibility and analysis of metrological demand for ultrasound services, hydrophone calibration using sweeps, coded pulse excitation and acoustic pressure field mapping.

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