Report on the NMIA national standards

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Status of national standards
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Primary Pressure Calibration of Microphones by Reciprocity

The National Measurement Institute, Australia (NMIA) established a three-port coupler reciprocity calibration system in the 1980s for calibration of 1-inch and ½-inch standard microphones at 250 Hz, 500 Hz and 1000 Hz. This system has been in service for more than two decades and provides complete automated calibrations without manually interchanging the microphones using a three-aperture coupler. The principle and details of this coupler reciprocity technique have been described in the AIP Handbook of Condenser Microphones, Chapter 12, 1995. The software has recently been modified to work with Microsoft's QuickBasic using National Instrument's PCI-GPIB IEEE-488 interface card installed in a PC equipped with 3 GHz Pentium processor.

The two-port reciprocity calibration system based on Bruel & Kjaer type 5998, a band pass filter type 1617 and a HP voltmeter type 3458A is now routinely used as the primary standard for the determination of pressure sensitivity of LS1 and LS2 microphones in the frequency ranges 20 Hz to10 kHz and 20 Hz to 31.5 kHz respectively with a best expanded uncertainty of ± 0.04 dB in the mid-frequency range. Four NMIA fabricated ½-inch plane wave couplers of nominal lengths 3, 4, 5 and 6 mm are used as substitutes for the standard Bruel & Kjaer supplied couplers. The couplers' dimensions have been accurately characterised by the NMIA's length group. A large volume vessel and a peristaltic pump is used to set the air pressure inside the isolation chamber close to the standard pressure of 101.325 kPa. To minimise potential interference from low frequency noise or vibration, the system is mounted on an active anti-vibration table that operates with compressed air.

The NMIA's accreditation for carrying out these reciprocity measurements was confirmed by the Australia's national accreditation body, the National Association of Testing Authorities (NATA), after an external technical peer review last year. The NMIA also participated in the regional Key Comparison APMP.AUV.A-K3 on LS2P microphones using this technique for the mandatory frequencies 63 Hz to 25 kHz as well as optional 31.5 kHz frequency. The degree of equivalence of the NMIA results with the Key Comparison reference value was within the expanded uncertainties at all mandatory frequencies. At the optional 31.5 kHz, only three NMIs reported their results and the variations between their results was higher than expected from the expanded uncertainties.

Free Field Calibration of Microphones

At NMIA a small anechoic chamber built of double-brick/concrete construction and internally lined with 600 mm thick graded-density sound-absorber is used to calibrate microphones under free-field acoustic conditions. A substitution method using a calibrated reference microphone and a sound source consisting of a 10-inch coaxial loudspeaker is utilised to determine relative free-field frequency response of microphones. Because of the low signal-to-noise ratios and complexity of carrying out free-field reciprocity measurements, it has not been possible to periodically verify the free-field sensitivity of the reference microphone. So the need to have a new traceable calibration of reference microphone became obvious and a new Bruel & Kjaer type 4180 (LS2P) microphone was purchased to fulfil this need. It was arranged that it be delivered with free-field reciprocity calibration done at the Danish Primary Laboratory on Acoustics (DPLA). Immediately upon delivery, its pressure sensitivity levels from 16 Hz to 31.5 kHz were determined by the NMIA two-port reciprocity calibration system. From this pressure sensitivity data and the DPLA free-field

sensitivity values, a set of pressure to free-field corrections for this microphone were calculated. These corrections were observed to be in good agreement with the differences between the free-field and pressure sensitivity values given in the IEC 61094-7 Standard over the applicable frequency range. Pressure reciprocity measurements on this reference microphone and the constant pressure to free-field corrections are used to demonstrate on-going traceability. A new "working free-field reference" microphone Bruel & Kjaer type 4190 equipped with type 2669 preamplifier is used for day to day operations to reduce the risk of accidental damage to the type 4180 reference microphone during the substitution process. The type 4190 working reference microphone is calibrated periodically by free-field comparison with the 4180 reference microphone. New software that allows for automated measurements of free-field frequency response of microphones has been developed and validated. It is being used regularly for free-field calibration of NMIA's microphones as well as customers' microphones. The new software has been written in Agilent's VEE Pro version 8.0 graphical programming language and incorporates several improvements over the old software that was previously used for such work.

Ultrasound Power Standard

The NMIA has commissioned an ultrasound power measurement system based on radiation force balance technique for measuring the radiated power output of ultrasound transducers in the frequency range 0.5 MHz to 25 MHz. It is a primary standard and has been built and validated by the NPL (UK) prior to delivery. The system utilises a Sartorius ME225S analytical balance with a resolution of 0.01 mg and an overall capacity of 230 g. Two absorbing targets formed of a polyurethane rubber material (HAM A configuration and F28P) of 80 mm diameter are available and can be used for measurement of the power. An aluminium framed enclosure with Perspex panels with two hinged front doors and a large damped base plate supported on four damped feet are used for access to the water tank and for setting up the transducers. A supply of distilled water is available in the laboratory and the water is degassed by boiling prior to its use in the water tank. Four transducers operating at the nominal frequencies of 1, 3, 7.5 and 15 MHz have been purchased and were calibrated by the NPL by measuring their power output against their primary standards. The NMIA has also measured the output of the 1 MHz and 3 MHz transducers for different applied voltages and were able to achieve results that are in good agreement with those of the NPL. The software for the measurements and calculations is based on LABVIEW graphical language and has also been validated by the NPL. The estimated overall uncertainties for the ultrasound power measurements are 4-5 % in the 20 mW to 50 mW range, 3-5 % for above 50 mW and 5-8 % for below 20 mW. The NMIA plans to participate in the CCAUV.U-K3 inter-comparison on ultrasound power measurements and will use this system together with a Rohde & Schwarz URE3 voltmeter for voltage measurements.

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