Report on the NMIA national standards

National Measurement Institute
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Status of national standards
(cf. Draft Agenda of 27/4/06, item 9.1)

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.

Recently a two-port reciprocity calibration system based on Bruel & Kjaer type 5998, a band pass filter type 1617 and a HP voltmeter type 3458A has also been commissioned into service and allows 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 ½-inch plane wave couplers of nominal lengths 3, 4, 5 and 6 mm have been fabricated in-house using fused silica and without capillary tubes, and 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 namely 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 has received accreditation from the Australia's national accreditation body, the National Association of Testing Authorities (NATA), for carrying out these reciprocity calibrations. The NMIA participated in the regional Key Comparison APMP.AUV.A-K1 on LS1P microphones using this technique for the frequencies 63 Hz to 8 kHz. The degree of equivalence of the NMIA results with the Key Comparison reference value was within the expanded uncertainties at all frequencies. Both three-port and two-port reciprocity techniques are currently in use at the NMIA and the results show good agreement when microphone pressure sensitivities measured using the two methods are compared. Results for the last three years for a Bruel & Kjaer type 4180 microphone, serial no. 2101406, using both reciprocity methods at octave frequencies are shown below.

Freq, Hz	Sensitivity, dB (2004)		Sensitivity, dB (2005)		Sensitivity, dB (2006)	
31.5	-37.916		-37.903		-37.890	
63	-37.933		-37.918		-37.905	
125	-37.938		-37.925		-37.915	
250	-37.934	-37.887	-37.933	-37.879	-37.921	-37.878
500	-37.941	-37.909	-37.937	-37.904	-37.925	-37.899
1 k	-37.949	-37.962	-37.934	-37.957	-37.922	-37.955
2 k	-37.923		-37.911		-37.899	
4 k	-37.817		-37.806		-37.794	
8 k	-37.446		-37.436		-37.425	
16 k	-37.337		-37.331		-37.333	
31.5 k	-44.956		-44.876		-44.998	

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. The traceability of calibration of the reference microphone Bruel & Kjaer type 4161 dates back to the free-field reciprocity measurements published by Gibbings and Gibson in Metrologia in 1984 (Volume 20, pp 85-94). Because of the low signal-to-noise ratios and complexity of making such free-field reciprocity measurement, it has not been possible to periodically verify the free-field sensitivity of the reference microphone. Furthermore, most sound-pressure level measurements these days are made using ½-inch microphones rather than 1-inch microphones so the need to have a new traceable calibration of ½-inch reference microphone became obvious.

To demonstrate ongoing traceability of free-field calibrations done at the NMIA, a new Bruel & Kjaer type 4180 (LS2P) microphone was purchased in 2005. 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 Working Draft 10 over the applicable frequency range. Future traceable calibrations will rely upon repeats of pressure reciprocity measurements as the pressure to free-field corrections are dependent on physical dimensions of the microphone only and are expected to remain constant with time. A “working free-field reference” microphone Bruel & Kjaer type 4190 with type 2669 preamplifier has been introduced 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. The calibration uncertainties have also been re-calculated to take the above changes into account.

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