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**Improved precision in acoustic impedance measurements by using
calibration loads without resonances**

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Although the input impedance of a one-dimensional waveguide is simply defined by the ratio of pressure to volume flow measured at its input, the deficiencies of available transducers require a more complicated approach for precise measurements. These can involve multiple transducers at points within an impedance head connected to the measured load. However, resonances and/or singularities during calibration and/or measurement often limit the precision of acoustic impedance spectra. This paper reviews and compares several established techniques, and describes a technique that incorporates three features that can considerably improve precision. The first feature involves minimising the problems due to resonances by calibrating the instrument using up to three different acoustic reference impedances that do not themselves exhibit resonances: an acoustically infinite waveguide, an acoustic open circuit and an acoustically infinite flange. The second feature involves using multiple pressure transducers to reduce the effects of measurement singularities. The third involves iteratively tailoring the spectrum of the stimulus signal to control the distribution of errors across the particular measured impedance spectrum. Examples are given of the performance of the technique on simple cylindrical waveguides and some wind instruments, including the saxophone and clarinet.