Signals and Systems

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A New Audiometric Bone Vibrator
- Radioear B81 for more accurate hearing diagnostics

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Objective

The objective was to evaluate the electro-acoustic performance of the new audiometric bone vibrator Radioear B81 (Radioear Corporation, New Eagle, PA, USA). Comparison was made with the present Radioear B71 that has some well-known limitations at low frequencies.

Introduction

A hearing investigation of a patient with a suspected hearing loss comprises air and bone conduction threshold testing. Bone conduction hearing testing is used for assessing the degree of sensory neural hearing loss and has been performed using the Radioear B71 bone vibrator ever since the 1970'ties.
However, the B71 is known to give less accurate results at frequencies below 1 kHz due to distortion and limited output.

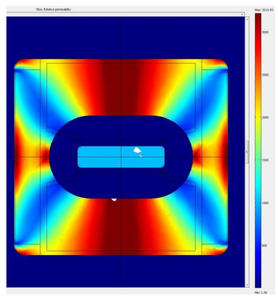
B71

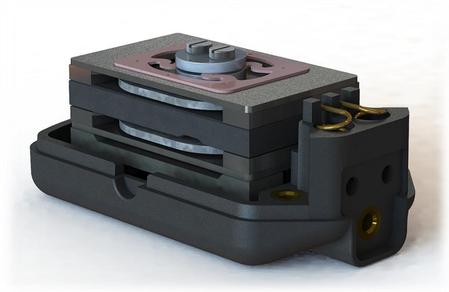
B81

In an attempt to improve the low frequency performance, a new transducer principle called Balanced Electromagnetic Separation Transducer (BEST) was developed by Håkansson (2003). This is the motor unit used in the new B81 bone vibrator. Using the BEST™ principle, the static forces are counterbalanced so that non-linear distortion forces are reduced and maximum output levels can be increased.

Design of the B81

In a collaboration between Ortofon A/S, Nakskov, Denmak, and Chalmers University of Technology, Sweden, the BEST™ design has been further optimized using, for example, computer simulations (left) and the motor unit as well as the casing and electrical contacts (right) has been adapted for efficient serial production.





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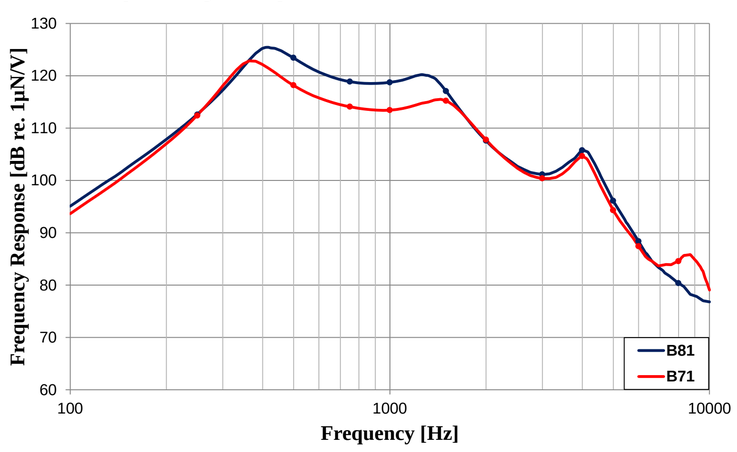
Methods

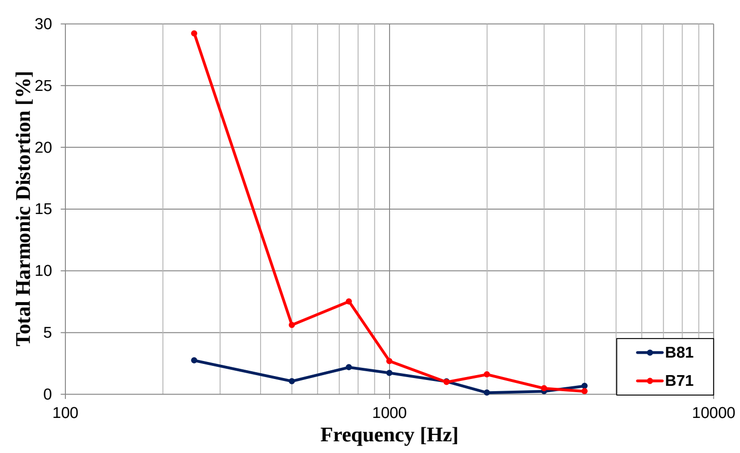
Frequency response, total harmonic distortion (THD), maximum output and electrical impedance were measured for three devices of each type (B71 and B81) on an artificial mastoid Brüel & Kjær 4930 where the bone vibrators were attached with a static force of 5.4 N according to ISO 389-3.
Compensation for the transmission thru the pad to the gauge of the artificial mastoid was made by post processing in all measurements.

Results and Discussion

Frequency response @ 1 V_{RMS}

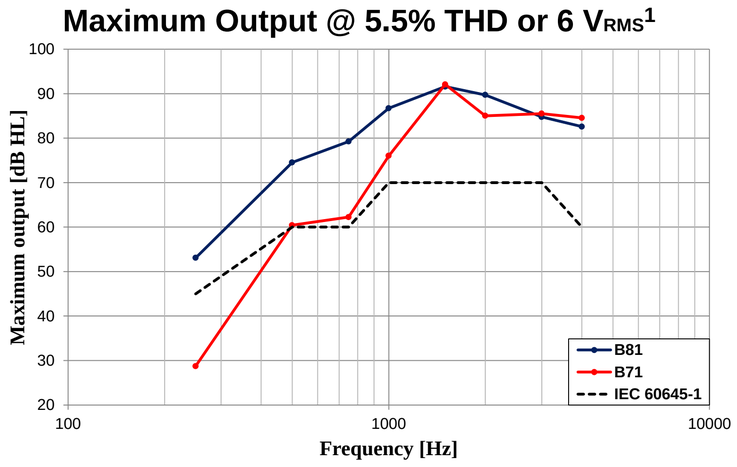


Total Harmonic Distortion @ 1 V_{RMS}

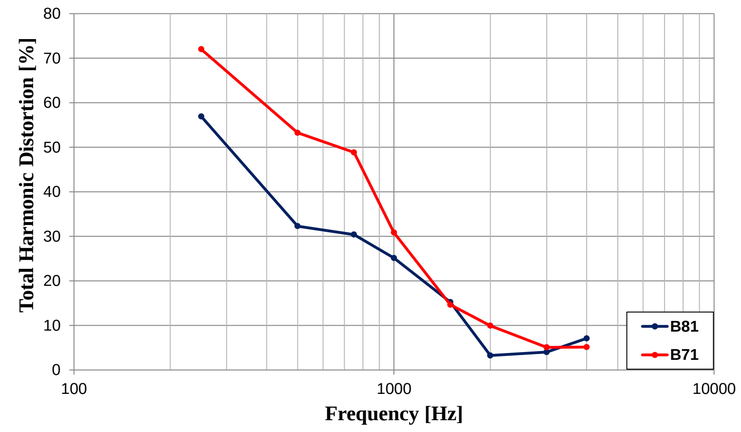


The frequency response of the B81 was designed to replicate the B71 and it was found that they were practically identical (median values of three devices) except for a small deviation at the mid frequencies where the B81 is more efficient (left). The THD was considerably lower for the B81 at low frequencies (right) when driven by a constant voltage of 1 V_{RMS}.

Maximum Output @ 5.5% THD or 6 V_{RMS}[1]



Total Harmonic Distortion @ 1 V_{RMS}
Compensated for dB HL



[1] Maximum output hearing level measured according to IEC 60645-1 (5.5 % recently updated to 6 %) and industrial recommendation (6 V_{RMS})

Most importantly, it was found that the B81 can produce 10-24 dB higher maximum output hearing levels than the B71 for frequencies up to 1 kHz (measured at THD=5.5 % or V_{in}=6 V_{RMS} whichever comes first). Above 1 kHz, the two devices are more similar. At 250 Hz, the B81 (median 53 dB HL) met the IEC 60645-1 requirements (45 dB HL) whereas the B71 (median 29 dB HL) failed. When the THD is compensated for the actual hearing sensitivity of the harmonics (dB HL difference), it is obvious that distortion at low frequencies is a serious problem where improvements are called for (right).

Conclusions

It was found that the new B81 may offer a new era in low frequency bone conduction audiometry as:

- **The B81 has generally lower distortion and higher output than the B71 below 1.5 kHz**
- **Bone threshold testing at 250 Hz can now be recommended for routine diagnostics**

In future studies, the acoustically radiated noise from the bone vibrator casing, static force dependence, drop testing and tactile thresholds will be investigated.

References

Håkansson B., 2003, The balanced electromagnetic separation transducer: A new bone conduction transducer. J. Acoust. Soc. Am. 113 (2), pp 818-825.