



Test Bench

By Vance Dickason

Audience was founded in November 1997 as a design and manufacturing company focused on building high-end audio and video equipment. The company manufactures a line of interconnect cables, an optical disk resolution enhancement device (the Auric Illuminator), audiophile grade capacitors, power conditioners, class D amp and tapped transformer preamp, as well as a line of line source array loudspeakers.

Audience A3

This month's driver from Audience, the A3 (**Photo 1**), is the company's first OEM driver offering and is the same driver used in their line source loudspeaker line. This 3" diameter full-range loudspeaker driver design is composed of the dual gap XBL motor, patent-pending suspension, and patent-pending frame. The patented XBL motor configuration and patent-pending surround are both licensed from ADI (Acoustic Development International), and are patents from Dan Wiggins group (formerly Adire). The XBL motor structure (**Fig. 1**) is a dual gap design using a single shaped front plate. In the case of the Audience A3, two plates are sandwiched together to get the same effect. The S-shaped patent-pending surround is also an ADI invention. Audience's proprietary, patent-pending frame supports the structure while free of typical design resonances, is unobtrusive, and avoids trapped air volumes.



PHOTO 1: Audience A3.

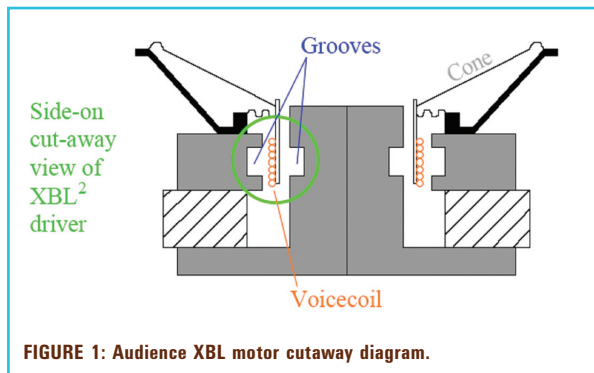


FIGURE 1: Audience XBL motor cutaway diagram.

Mechanical design of the frame was refined using Finite Element Analysis, with the goal of minimizing mechanical resonance problems. The A3 cone is an anodized aluminum magnesium alloy curvilinear design combined with a large concave dust cap covering about 80% of the cone area, which forms an extremely stiff arrangement. In order to control high-frequency breakup, an important concept in a full-range driver, Audience utilized a proprietary dustcap material that includes constrained layer damping to damp break-up modes and improve high-frequency dispersion. Motor features include a neodymium ring magnet and a 25mm diameter voice coil wound with copper wire on an aluminum former.

I began analysis of the A3 using the LinearX LMS analyzer and VIBox to produce both voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 0.3V, 1V, 3V, 6V, and 10V. As has become the protocol for Test Bench testing, I no longer use a single added mass measurement and instead used actual measured mass, but the manufacturer's physically measured Mmd data. I would have expected a small driver such as the A3 to be pretty much "out of gas" by 6V in free-air, but I was able to get usable 10V, which is impressive.

With the ten-curve measurement set finished, I post-processed the 550-point stepped sine wave sweeps for two A3 samples and divided the voltage curves by the current curves (admittance) to derive impedance curves, phase added by the LMS calculation method, and, along with the accompanying voltage curves, imported to the LEAP 5 Enclosure Shop software. Because most Thiele/Small data provided by OEM manufacturers is being produced using either a standard method or the LEAP 4 TSL model, I also produced a LEAP 4 TSL model using the 1V free-air curves. I selected the completed curve

Table 1 Audience A3

	TSL model sample 1	sample 2	LTD model sample 1	sample 2	Factory
F _s	59.1Hz	62.0Hz	59.3Hz	60.8Hz	70Hz
R _{EVC}	12.79	12.64	12.79	12.64	13
S _d	0.0028	0.0028	0.0028	0.0028	0.0032
Q _{MS}	0.93	1.07	1.03	1.09	1.18
Q _{ES}	0.44	0.47	0.50	0.50	0.52
Q _{TS}	0.30	0.32	0.34	0.34	0.36
V _{AS}	3.5 ltr	3.18 ltr	3.5 ltr	3.4 ltr	3 ltr
SPL 2.83V	84.0dB	83.9dB	83.5dB	83.5dB	81.9dB
X _{MAX}	6.0mm	6.0mm	6.0mm	6.0mm	6.0mm

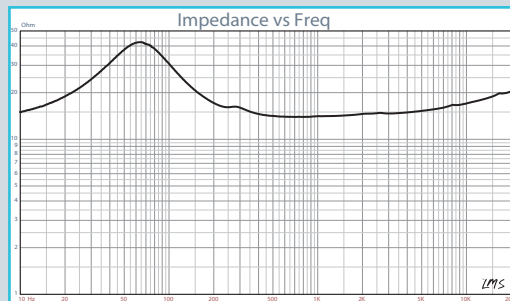


FIGURE 2: Audience A3 woofer free-air impedance plot.

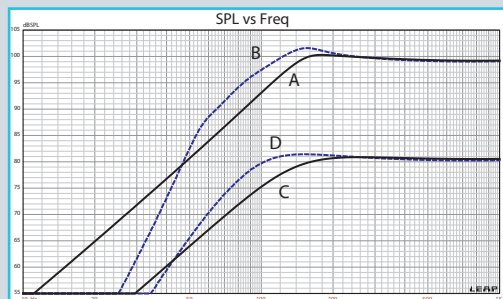


FIGURE 3: Audience A3 computer box simulations (A = sealed at 2.83V; B = vented at 2.83V; C = sealed at 30V; D = vented at 30V).

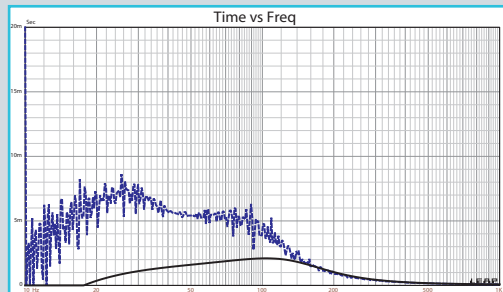


FIGURE 4: Group delay curves for the 2.83V curves in Fig. 2.

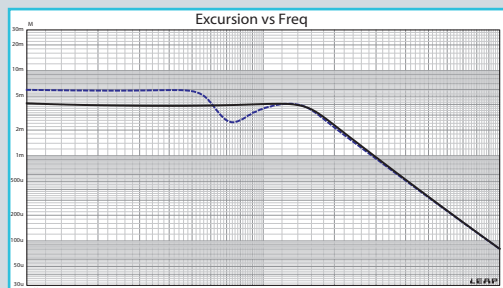


FIGURE 5: Cone excursion curves for the 30V curves in Fig. 2.

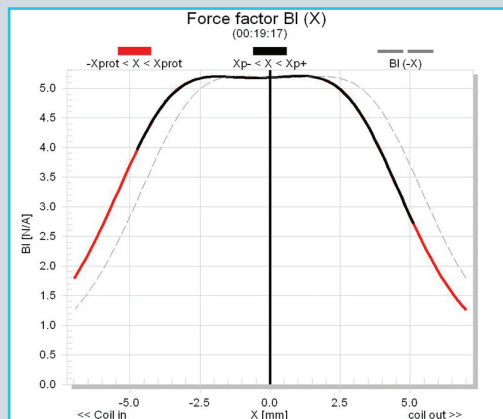


FIGURE 6: Klippel Analyzer BI (X) curve for the Audience A3.

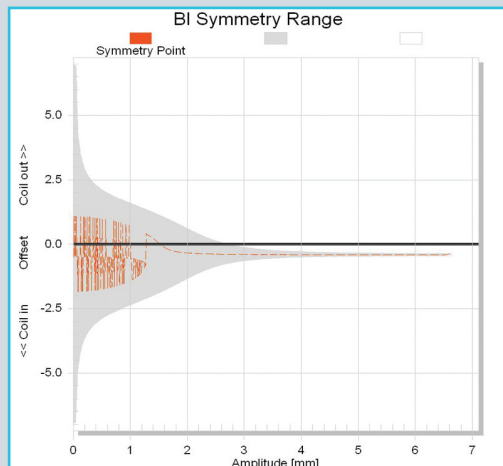


FIGURE 7: Klippel Analyzer BI symmetry range curve for the Audience A3.

set, the multiple voltage impedance curves for the LTD model (see **Fig. 2** for the 1V free-air impedance curve) and the 1V impedance curve for the TSL model in the Transducer Derivation menu in LEAP 5, and calculated and used the parameters to generate computer box simulations. **Table 1** compares the LEAP 5 LTD and TSL data and factory parameters for both A3 samples.

With good correlation between my measurements and the published factory data, I next produced computer enclosure simulations using the LEAP LTD parameters for Sample 1. The two box simulations included a 48 in³ sealed box with 50% fiberglass fill material, and an 86 in³ Qb3 vented enclosure with 15% fiberglass fill material and tuned to 69Hz.

Figure 3 gives the outcome for the A3 loaded in the sealed and vented boxes at 2.83V and at a voltage level high enough to increase cone excursion to X_{max} + 15% (6.9mm). This generated a F3 frequency of 122Hz with a box/driver Q_{tc} of 0.67 for the 48 in³ sealed enclosure and -3dB = 89.7Hz for the 86 in³ vented simulation. For the maximum output curves I chose to limit the voltage level to 30V. This 3" driver is designed to work in multiples in an array. However, a single driver is most likely thermally limited before reaching its maximum excursion, given that increasing the voltage input to the simulations to 30V produced 100dB for the sealed enclosure simulation and 102 for the larger vented box (see **Figs. 4** and **5** for the 2.83V group delay curves and the 30V excursion curves).

Klippel analysis for the Audience woofer (our analyzer is provided courtesy of Klippel GmbH), performed by Pat Turnmire, Red Rock Acoustics (author of the SpeaD and RevSpeaD software), produced the BI(X), Kms(X), and BI and Kms symmetry range plots given in **Figs. 6-9**. This data is extremely valuable for transducer engineering, so if you don't own a Klippel analyzer and would like to have analysis done on a particular driver project, Red Rock Acoustics can provide Klippel analysis for a nominal fee (www.redrockacoustics.com).

The BI(X) curve for the A3 (**Fig. 6**) is very broad and symmetrical, typical of a high X_{max} driver, with a small rearward (coil-in) offset. Looking at the BI symmetry plot (**Fig. 7**), this curve shows a coil inward offset of about 0.35mm from about 2mm outward and stays constant throughout the remaining operating range of the driver. **Figures 8** and **9** depict the Kms(X) and Kms symmetry range curves for the A3 woofer. The Kms(X) curve is moderately symmetrical with a small forward offset of about 0.81mm at the rest position that decreases throughout the remaining operating range—not a problem.

Displacement limiting numbers calculated by the Klippel analyzer for the A3 were X_{BI} at 82% BI = 3.6mm and for X_C at 75% C_{ms} minimum was 2.0mm, which means that for this 3" woofer, the compliance is the most limiting factor for a prescribed distortion level of 10%. Again, you must keep in mind that this driver is not intended to operate solo, so in multiples, the distor-

tion levels would be proportionately smaller.

Figure 10 gives the inductance curves $L_e(X)$ for the Audience driver. Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area. However, that applies to a standard motor, and the XBL motor is substantially different and yields a very different $L_e(X)$ curve. The key element here is that the inductance variation from rest to maximum excursion in either direction is only 0.035mH—practically nothing.

Next I mounted the A3 woofer in an enclosure which had a 13" × 4" baffle area (filled with Acousta-Stuf absorption material) and then measured the driver on-

and off-axis from 300Hz to 40kHz frequency response at 2.83V/1m using the LinearX LMS analyzer set to a 100 point gated sine wave sweep. **Figure 11** depicts the A3's on-axis response indicating a smoothly rising response out to above 20kHz (remember, this is a full-range driver intended for use without the addition of a tweeter) with a 6dB peak at 8.2kHz and a broad 10dB peak between 16.5kHz-23.2kHz. **Figure 12** displays the on- and off-axis frequency response at 0, 15, 30, and 45°. -3dB at 30° with respect to the on-axis curve occurs at 6kHz, so a crosspoint in that vicinity or lower should be optimal if you were making this a two-way speaker.

As a full-range, it's as competent as any of the small

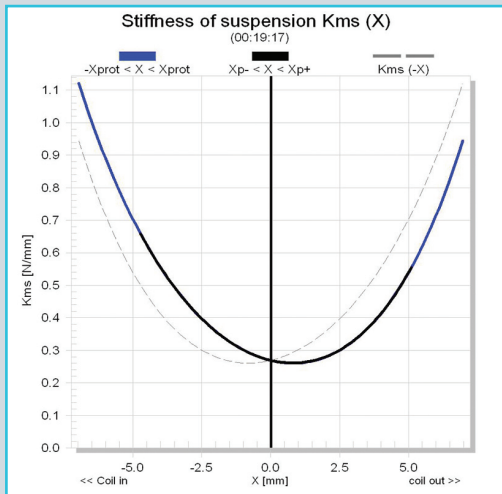


FIGURE 8: Klippel Analyzer mechanical stiffness of suspension $K_{ms}(X)$ curve for the Audience A3.

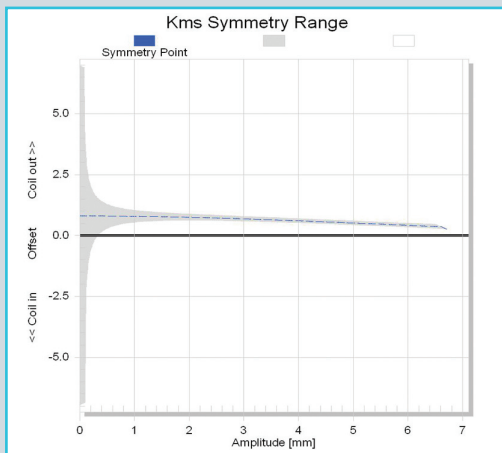


FIGURE 9: Klippel Analyzer K_{ms} symmetry range curve for the A3.

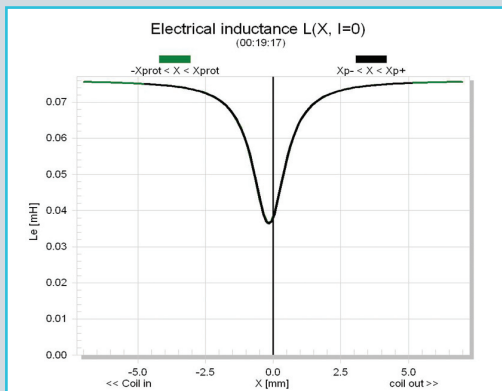


FIGURE 10: Klippel Analyzer $L_e(X)$ curve for the Audience A3.

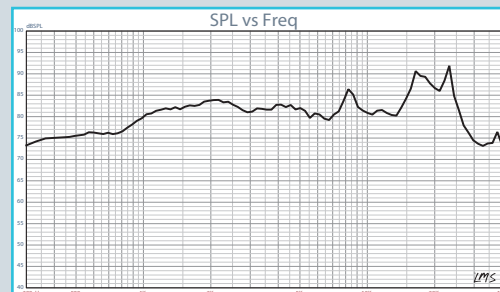


FIGURE 11: Audience A3 on-axis frequency response.

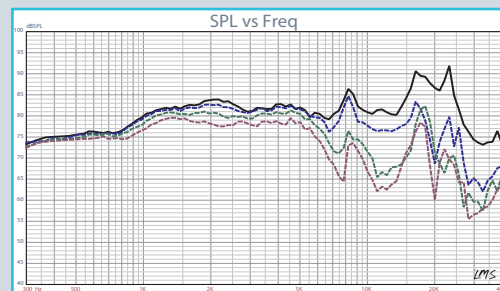


FIGURE 12: Audience A3 on- and off-axis frequency response.

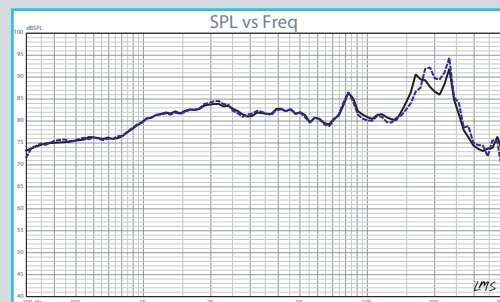


FIGURE 13: Audience A3 two-sample SPL comparison.

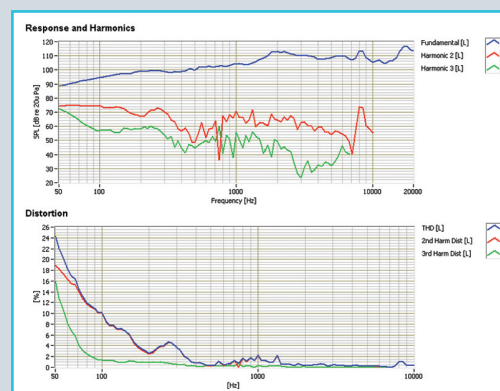


FIGURE 14: Audience A3 SoundCheck distortion plot.

multi-driver systems to come along such as the Jordan Module or Bandor products. However, no matter what, you can't fight Mother Nature and physics. The power response of a 3" driver just isn't as good as a 1" driver. That said, there has been a following for full-range speakers for years, and this includes not only small drivers such as the A3, but even 8" full-range drivers from Fostex and now SEAS that find customers who are ecstatic about their performance. Of course, this begs the question of musical realism versus directivity, which in itself is an extremely interesting subject. Last, **Fig. 13** gives the two-sample SPL comparisons for the A3 driver, showing a very close match throughout the operating range.

For the final battery of tests, I employed the Listen Inc. SoundCheck analyzer (courtesy of Listen Inc.) to measure distortion and generate time frequency plots. For the distortion measurement, I mounted the woofer rigidly in free-air, and set the SPL to 88dB at 1m using a noise stimulus, and then measured the distortion with the Listen Inc. microphone placed 10cm from the dust cap. Normally, this would have been 94dB, but because this driver will always be used in multiples, I lowered the SPL by 6dB to be fairer to the product. At 5.82V, this produced the distortion curves shown in **Fig. 14**. Following the distortion measurement, I used SoundCheck to get a 2.83V/1m impulse response for this driver and imported the data into Listen Inc.'s SoundMap Time/Frequency software. The resulting CSD waterfall plot is given in **Fig. 15** and the Wigner-Ville (for its better low-frequency performance) plot in **Fig. 16**. **VC**

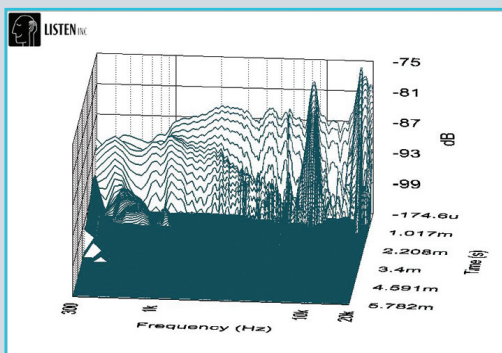


FIGURE 15:
Audience A3
SoundCheck
CSD water-
fall plot.

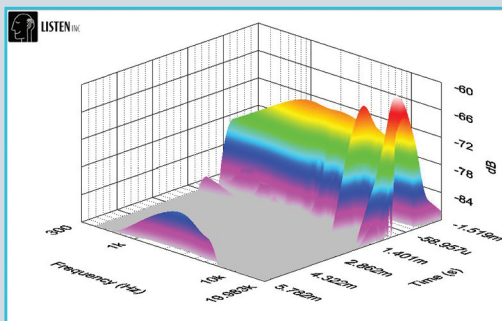


FIGURE 16:
Audience A3
SoundCheck
Wigner-Ville
plot.