SPOTLIGHT ON CONE VENDORS, p. 10

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VOICE COIL

THE PERIODICAL FOR THE LOUDSPEAKER INDUSTRY

IN THIS ISSUE

Industry News & Developments

By Vance Dickason

New Features for LOUDSOFT's FINECone

If you aren't familiar with LOUDSOFT's FINECone software, it is an outstanding acoustic finite element dome/cone simulation program (see **Figure 1**). This software enables users to build a finite element wire mesh model and then observe the attributes of the cone or dome such as sound pressure level (SPL), directivity, impedance, and 3-D animation. There are many applications for this program including:

- Curvilinear cone analysis
- Variable cone thickness
- Bent cone edges
- Cone reinforcement ribs
- Complex curve cones
- Sandwich cones
- Inverted cones
- Virtual cone material analysis
- Exotic materials (e.g., carbon, boron, beryllium, etc.)
- Large dust cap analysis
- Inverted dust caps
- Whizzer cones
- Glue joint modeling
- Up and down roll surrounds with compliance
- Variable thickness surrounds
- S- and M-shape surrounds
- Asymmetric/variable surround geometries
- Dome tweeter simulations (above 50 kHz)

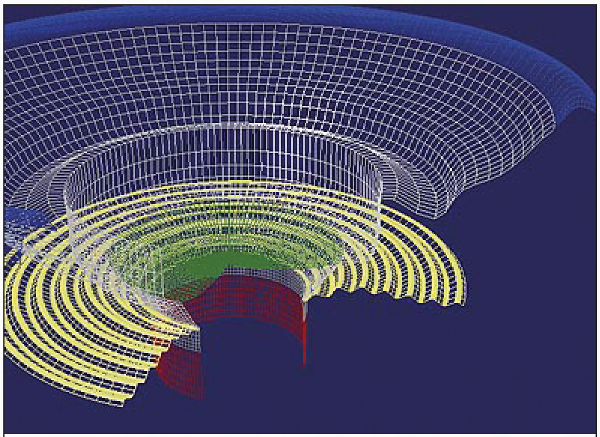

Figure 1: FINECone wire mesh cone animation drawing

- Inverted dome simulations
- Domes with smaller-than-dome voice coils
- W-cones
- Mini speakers and headphones
- Micro receivers for mobile phones
- Infrasound and ultrasound simulations (1–100 kHz)
- Spider compliance calculations
- Voice coil and former mass and stiffness
- Impedance calculation with reflections
- Dispersion analysis

Recently, LOUDSOFT has added additional program capabilities. FINECone now designs rectangular and oval speakers (see **Figure 2**). The software also enables users to design oval motors and voice coils (see **Figure 3** and **Figure 4**). In addition, the top plates of inside neodymium motors can be offset by rolling the mouse wheel (see

A Celestion Line Array Driver and an 18 Sound Compression Driver

By Vance Dickason

The Celestion AN2075 is part of a three-model line of array drivers. The AN2075 has a 2”-diameter aluminum cone neodymium motor full-range transducer primarily intended for use in line source arrays. (Celestion’s AN3510 was featured in *Voice Coil*’s September 2013 issue.)

The AN2075 is built on a proprietary six-spoke molded-glass reinforced ABS frame that includes six screen-covered 3 mm × 10 mm voice coil cooling vents, which are located below the spider mounting shelf and between the frame spokes (see **Photo 1**). The cone assembly consists of a black anodized aluminum cone with a 19-mm diameter aluminum dust cap and whizzer-type extension. Suspending the cone and the dust cap is a low-loss nitrile butadiene rubber (NBR) surround and a 34-mm diameter treated cloth flat spider.

The AN2075 has a 20-mm diameter two-layer voice coil wound with copper wire on a nonconducting polyimde former attaching to a pair of aircraft-type terminals. Powering this structure is an overhung neodymium motor with a ventilated (four 2-mm vent holes) motor return cup for better heat transfer to the surrounding air.

I clamped the driver to a rigid test fixture in free air at 0.3, 1, 3, and 6 V and used the LinearX LMS analyzer and VIBox to create voltage and admittance (current) curves. Next, I post-processed the eight 550-point stepped sine wave sweeps (four current and four voltage sweeps) for each AN2075 sample. Then, I divided the voltage curves by the current curves (admittance curves) to produce the impedance curves, which were phase generated by the LMS calculation method.

Next, I imported them along with the accompanying voltage curves into the LEAP 5 Enclosure Shop software. Most Thiele-Small (T-S) data provided by OEM manufacturers is produced using either a standard transducer model or the LEAP 4 TSL model so I used the 1-V free-air curves to create a LEAP 4 TSL model. From LEAP 5’s transducer derivation menu, I selected the complete data set, the LTD model’s multiple voltage impedance curves, and the TSL model’s 1-V impedance curve and created the parameters for the computer box simulations. **Figure 1** shows the 1-V free-air impedance curve. **Table 1** compares the LEAP 5 LTD and TSL data and Celestion factory parameters for both the AN2075 samples.

Photo 1: The Celestion AN2075 is a full-range transducer primarily intended for use in line source array drivers.

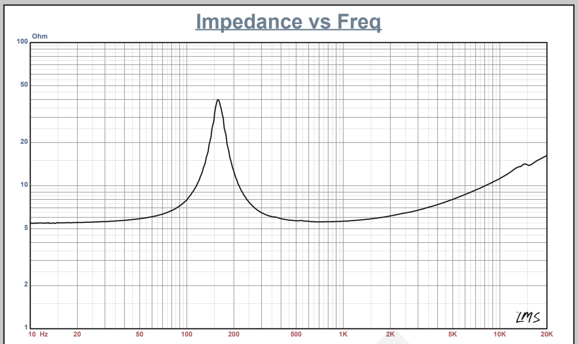

Figure 1: Celestion AN2075 array woofer 1-V free-air impedance plot

	TSL Model		LTD Model		Factory
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	159 Hz	177 Hz	152 Hz	148 Hz	160 Hz
R_{EVC} (series)	5.22	5.14	5.22	5.14	5.28
Sd	0.0013	0.0013	0.0013	0.0013	0.0013
Q_{MS}	7.69	8.45	8.02	7.82	10.12
Q_{ES}	1.12	1.18	1.42	1.36	1.22
Q_{TS}	0.98	1.04	1.21	1.16	1.09
V_{AS}	0.16 ltr	0.13 ltr	0.18 ltr	0.15 ltr	0.12 ltr
SPL 2.83 V	79.6 dB	79.8 dB	78.3 dB	79 dB	80 dB
X_{MAX}	1.5 mm	1.5 mm	1.5 mm	1.5 mm	1.5 mm

Table 1: Celestion AN2075 driver comparison data

The AN2075’s LEAP parameter calculation results were reasonably close to the factory data. The only real difference was some minor variation in the sensitivity rating, but mine is a calculated mid-band derived from the parameter measurement and Celestion’s is a half-space anechoic chamber measurement at 1 W/1 m.

Then, I used the LEAP LTD parameters for Sample 1 to set up the computer enclosure simulations. I programmed two computer box simulations into LEAP. The first simulation was a single AN2075 driver in a 61-in^3 sealed box alignment (50% fill material).

Figure 2 shows the second simulation, which was a

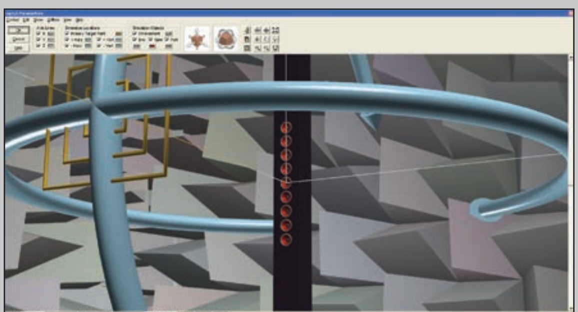

Figure 2: The LEAP 5 layout screen shows the Celestion AN2075 in a nine-driver line source array.

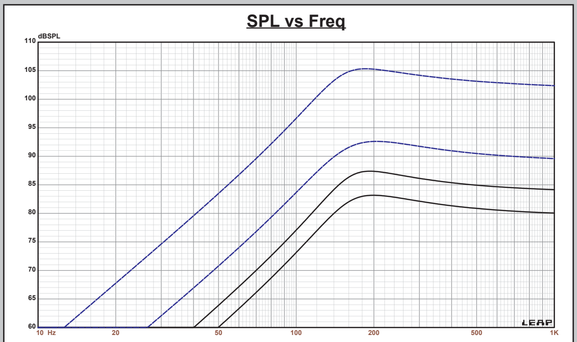

Figure 3: Celestion AN2075 computer box simulations (black solid = sealed single driver at 2.83 V; blue dash = sealed nine-driver array at 2.83 V; black solid = sealed single driver at 4.75 V; blue dash = sealed nine-driver array at 13.25 V)

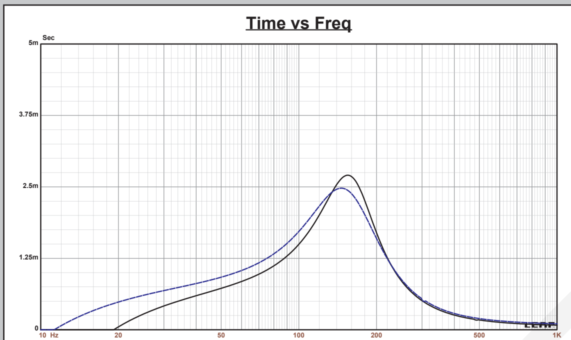

Figure 4: Group delay curves for the 2.83-V curves in Figure 3

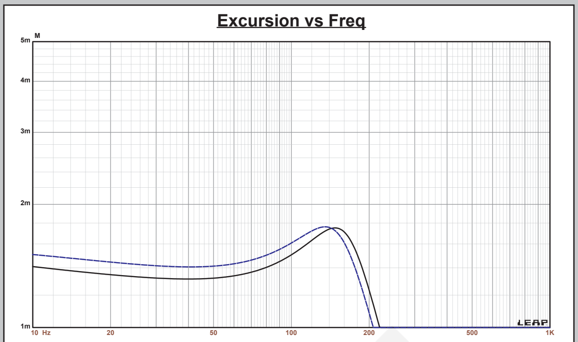

Figure 5: Cone excursion curves for the 4.75-V/13.25-V curves in Figure 3

nine-driver array with a total of 549 in^3 for the sealed enclosure (also with 50% fill material). **Figure 3** shows the results for the Celestion AN2075 full-range array driver in the two enclosure simulations at 2.83 V and at a voltage level sufficiently high enough to increase the cone excursion to 1.73 mm (X_{MAX} + 15%). This produced a F3 frequency of 140 Hz with a box/driver Qtc of 1 for the single-driver sealed enclosure and −3 dB = 137 Hz with a Qtc = 1 for the sealed-box nine-driver array simulation.

I increased the voltage input to the simulations shown in **Figure 3** until the maximum linear cone excursion was reached. This resulted with only 1.5-mm X_{MAX}, 87.5 dB at 4.75 V for the sealed enclosure simulation, and 105 dB with a 13.25-V input level for the larger nine-driver array. **Figure 4** and **Figure 5** show the 2.83-V group delay

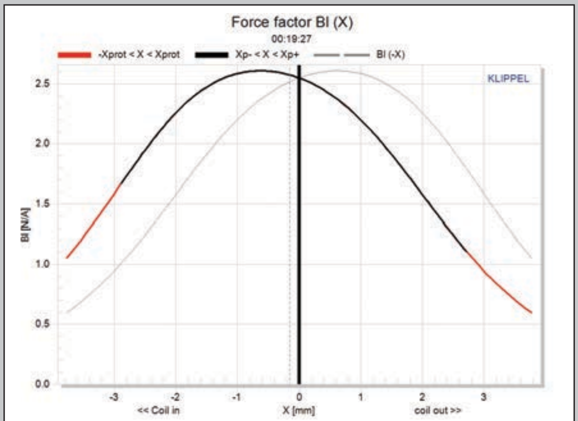

Figure 6: The Celestion AN2075's Klippel analyzer Bl (X) curve

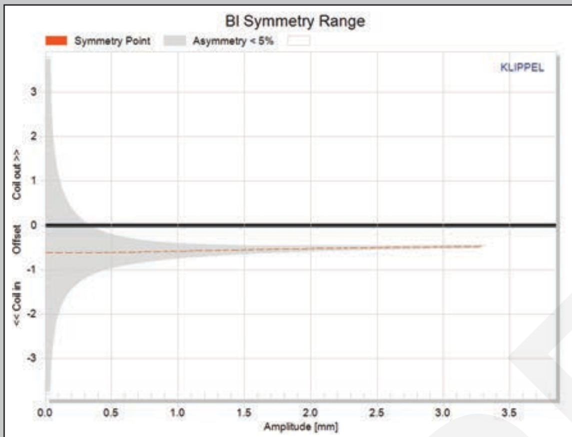

Figure 7: The Celestion AN2075's Klippel analyzer Bl symmetry range curve

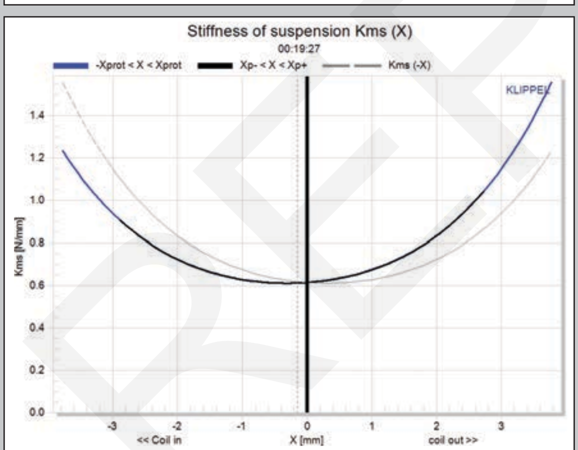

Figure 8: The Celestion AN2075's Klippel analyzer mechanical stiffness of suspension K_{MS} (X) curve

curves and the 4.75-V/13.25-V excursion curves).

The AN2075's Klippel analysis produced the Bl(X), K_{MS}(X) and Bl and K_{MS} symmetry range plots shown in **Figures 6–9**. (The analyzer I use for Test Bench is provided courtesy of Klippel. Pat Turnmire of Redrock Acoustics performs the testing). The AN2075's Bl(X) curve is relatively shallow, which is typical of any short X_{MAX} driver (as opposed to being broad and flat like a high X_{MAX} driver), as well as having a good degree of symmetry, but there is some obvious offset (see **Figure 6**). The Bl symmetry plot shows about 0.61-mm coil-in offset at the rest position that decreases to 0.54 mm at the driver's physical 1.5-mm X_{MAX} (see **Figure 7**). This small offset is mostly normal production variation. Given these drivers are not likely to perform in their piston range, I don't think this is much of an issue.

Figure 8 and **Figure 9** show the AN2075's K_{MS}(X) and K_{MS} symmetry range curves. The K_{MS} (X) curve is also symmetrical and has a very minor forward (coil-in) offset of about 0.3 mm at the rest position. The AN2075's displacement limiting numbers, calculated by the Klippel

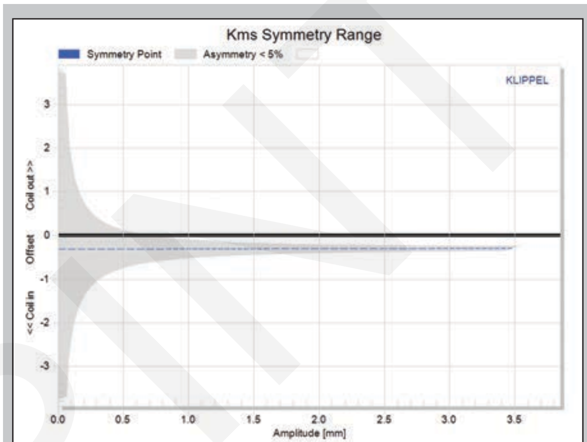

Figure 9: The Celestion AN2075's Klippel analyzer K_{MS} symmetry range curve

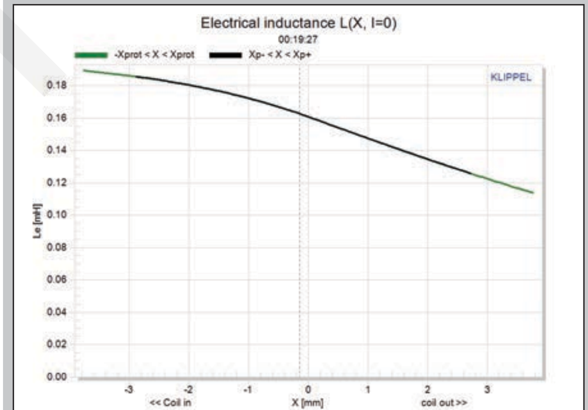

Figure 10: The Celestion AN2075's Klippel analyzer L(X) curve

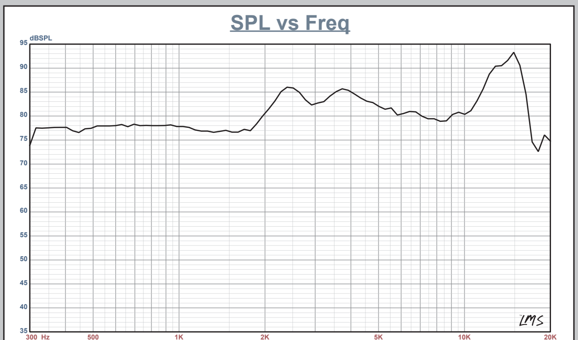

Figure 11: Celestion AN2075's on-axis frequency response

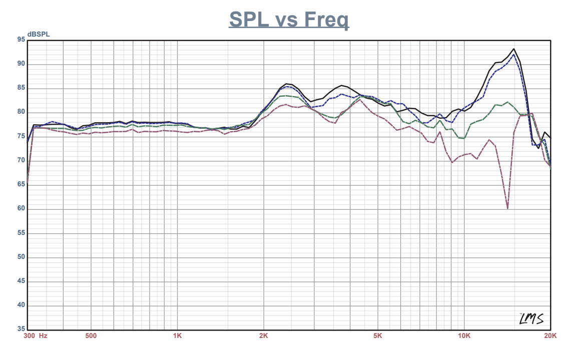

Figure 12: Celestion AN2075's on- and off-axis frequency response (black solid = 0°, blue dot = 15°, green dash = 30°, purple dash/dot = 45°)

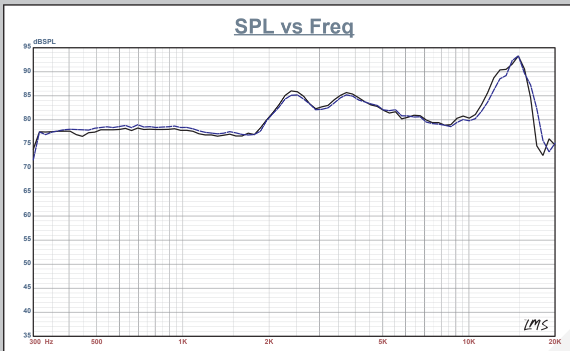

Figure 13: Celestion AN2075 two-sample SPL comparison

analyzer, were XBl at 82%, Bl = 1.2 mm. For the crossover at 75%, the C_{MS} minimum was 1.9 mm. For Celestion's AN2075, this means the Bl is the most limiting factor for the prescribed 10% distortion level and is somewhat less than the physical X_{MAX}.

Figure 10 shows the AN2075's inductance curve

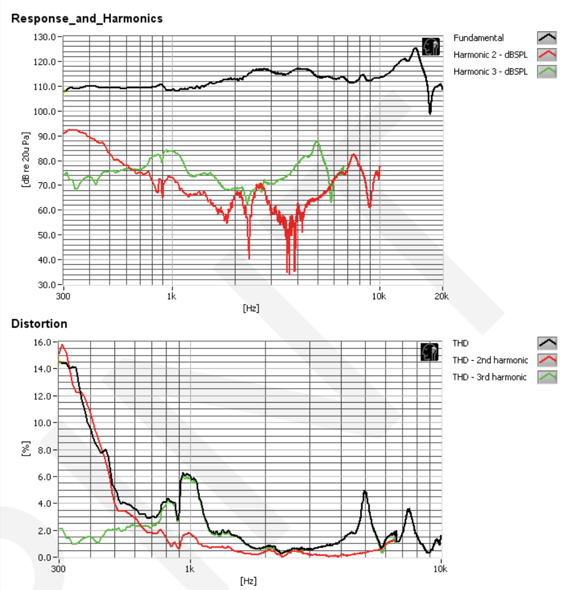

Figure 14: Celestion AN2075 SoundCheck distortion plot

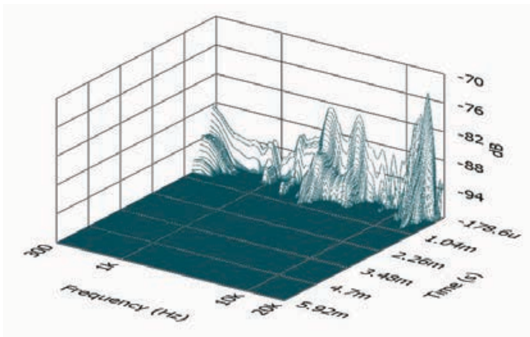

Figure 15: Celestion AN2075 SoundCheck CSD waterfall plot

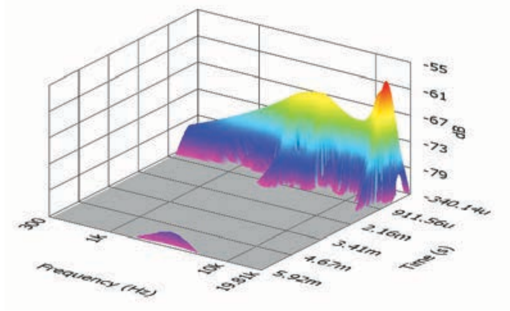

Figure 16: Celestion AN2075 SoundCheck Wigner-Ville plot

Photo 2: 18 Sound's ND4015BE compression driver is shown with the XR2064 horn.

Le(X). Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area. However, the AN2075's inductance variance due to the neodymium motor structure is rather small. The inductance variation is only 0.035 mH from the X_{MAXIN} and X_{MAXOUT} positions, which is very good.

Next, I mounted the AN2075 in an enclosure that had a 4" × 9" baffle filled with damping material (foam). I used the LinearX LMS analyzer set to a 100-point gated sine wave sweep to measure the transducer on- and off-axis from 300-Hz-to-40-kHz frequency response at 2.83 V/1 m. **Figure 11** shows the AN2075's on-axis response, which indicates a smoothly rising response to about 1.8 kHz with a couple of peaks at 2.4 kHz and 3.7 kHz, and some break-up peaking at 15 kHz prior the high-pass rolloff. **Figure 12** shows the on- and off-axis frequency response at 0°, 15°, 30°, and 45°. The driver demonstrates a really good off-axis response, better at 30° off-axis than the typical 1" dome device. Last, **Figure 13** shows the AN2075's two-sample sound pressure level (SPL) comparison, which is a close match to within less than 0.6 dB throughout the operating range.

For the remaining tests, I used the Listen SoundCheck analyzer with AmpConnect and the Listen 0.25" SCM microphone and power supply to measure the distortion and generate time-frequency plots. For the distortion measurement, I mounted the AN2075 rigidly in free air and used a noise stimulus to set the SPL to 94 dB at 1 m (14 V). Then, I placed the microphone 10 cm from the dust cap to measure the distortion. **Figure 14** shows the distortion curves.

I used SoundCheck to get a 2.83-V/1-m impulse

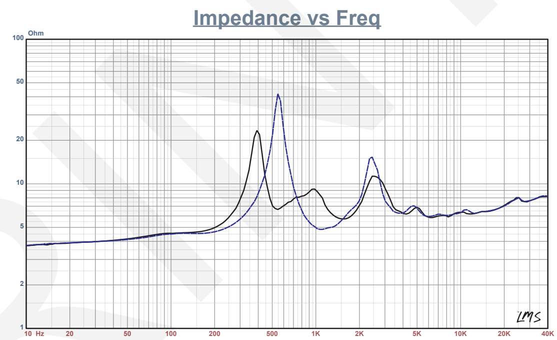

Figure 17: 18 Sound ND4015BE/XR2064 free-air impedance plot

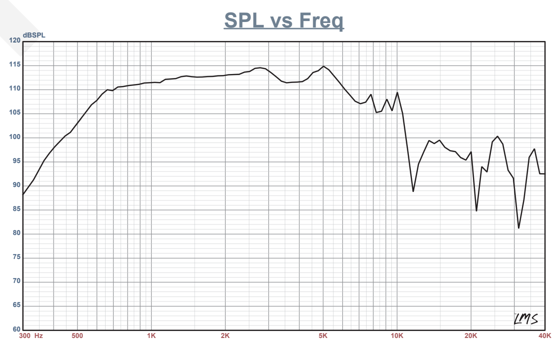

Figure 18: 18 Sound ND4015BE/XR2064 on-axis frequency response

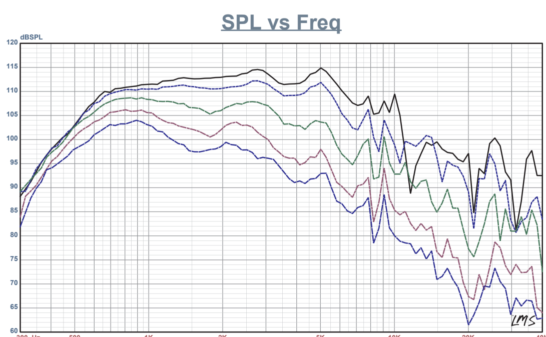

Figure 19: 18 Sound ND4015BE/XR2064 horizontal on- and off-axis frequency response (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot; 60° = dash)


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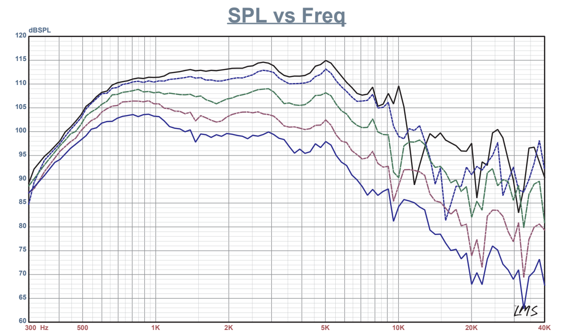

Figure 20: 18 Sound ND4015BE/XR2064 vertical on- and off-axis frequency response (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot; 60° = dash)

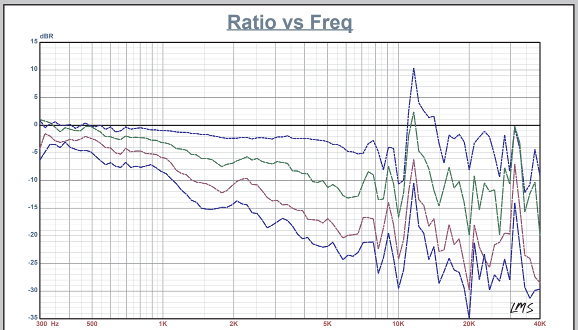

Figure 21: 18 Sound ND4015BE/XR2064 normalized horizontal on- and off-axis frequency response (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot; 60° = dash)

response and imported the data into Listens SoundMap time-frequency software (included with SoundCheck V. 12). **Figure 15** shows the resulting cumulative spectral decay (CSD) waterfall plot. **Figure 16** shows the Wigner-Ville plot, which I use for its better low-frequency performance.

The AN2075 is a well designed and well-crafted 2″ full-range array driver. Given the popularity of line arrays in both MI and PA applications, this is an important product line for Celestion. For more information, visit www.celestion.com.

The ND4015BE

The other driver I examined this month was 18 Sound's ND4015BE beryllium compression driver, which was mated to an 18 Sound XR2064 horn (see **Photo 2**). After recently completing a high-end two-channel speaker with a beryllium dome, I was excited to receive 18 Sound's new beryllium diaphragm compression driver.

This compressions driver is available in two versions, a 1.5″ throat and a 2″ throat. For this review, I tested the ND4015BE, which has a 2″ throat. In terms of features, the ND4015BE has a 2″ exit, a 4″-diameter edge-wound

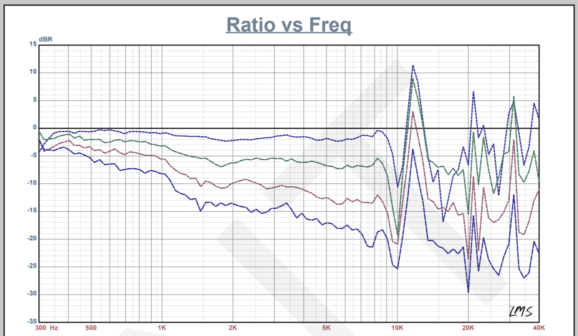

Figure 22: 18 Sound ND4015BE/XR2064 normalized vertical on- and off-axis frequency response (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot; 60° = dash)

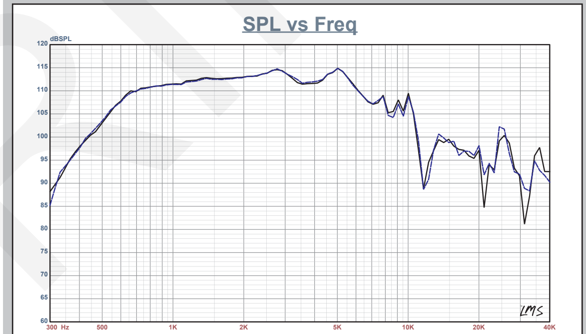

Figure 23: 18 Sound ND4015BE/XR2064 two-sample SPL comparison

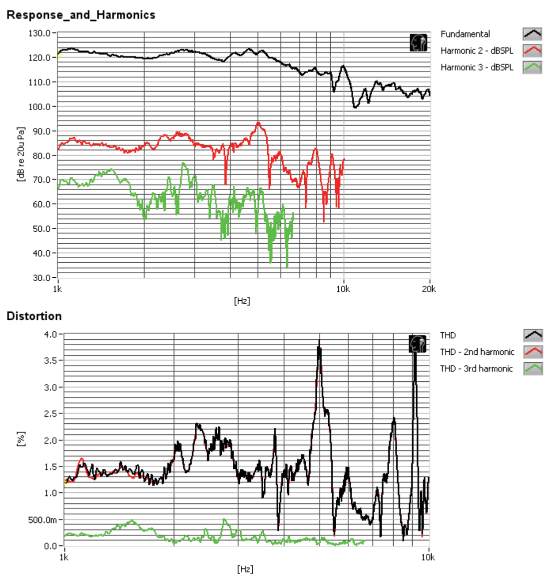

Figure 24: 18 Sound ND4015BE/XR2064 SoundCheck distortion plots

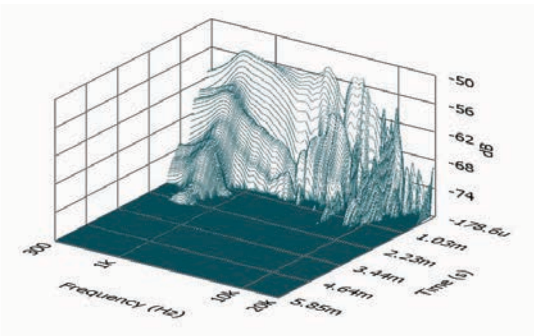

Figure 25: 18 Sound ND4015BE/XR2064 SoundCheck CSD waterfall plot

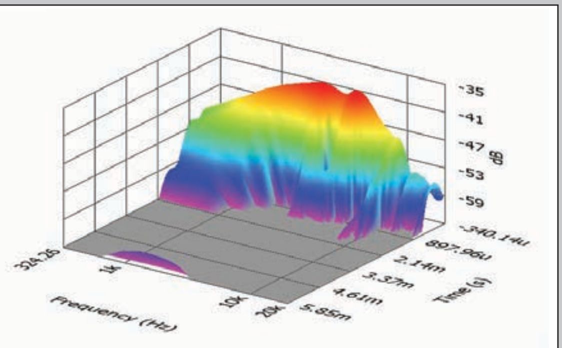

Figure 26: 18 Sound ND4015BE/XR2064 SoundCheck short-time Fourier transform (STFT) plot

aluminum voice coil on a nonconducting Nomex former, a 4″ pure beryllium diaphragm with a polymer surround, a copper-plated pole piece (shorting ring), a high-precision diaphragm centering system, and a boundary element method (BEM) optimized four-slot phase plug. The neodymium ring magnet, top plate, and bottom plate, plus the color-coded push terminals have a corrosion-resistant epoxy coating. For thermal dissipation, the entire motor structure is thermally coupled to the black aluminum top cover.

The XR2064 horn that 18 Sound provided with the ND4015BE is a 2″ entrance horn constructed of pressure-injected aluminum and painted black. As with all cast metal horns, it is capable of reducing the steady-state driver's working temperature at full power by up to 30°C, which increases the compression driver's power handling. The coverage pattern for this constant directivity horn is 60° × 40°.

I used the LinearX LMS analyzer to produce the 200-point stepped sine wave impedance plot shown in **Figure 17,** with and without the horn. The solid black curve represents the ND4015BE mounted on the XR2064 horn. The dashed blue curve represents the compression driver without the horn. With a 3.9-Ω DCR, the ND4015BE/XR2064 combination's minimum impedance was 5.7 Ω at 1.55 kHz.

For the next group of frequency response tests, I recess mounted the ND4015BE/XR2064 combination in an enclosure with a 10″ × 15″ baffle. Then, I used a 100-point gated sine wave sweep to measure the horizontal and vertical on- and off-axis at 2.83 V/1 m. **Figure 18** shows the compression driver/horn combination's on axis. The SPL profile measures ±2 dB from 1 to 6 kHz, before beginning its second low-pass rolloff at 5 kHz. The ND4015BE's recommended crossover frequency is a minimum of 900 Hz with a fourth-order LR network. In terms of the on- and off-axis response, the horizontal results at 0°, 15°, 30°, 45°, and 60° are shown in **Figure 19. Figure 20** shows the vertical on- and off-axis results.

Figure 21 and **Figure 22** show the plots with the off-axis normalized to the on-axis response for **Figure 19** and **Figure 20**, respectively. **Figure 23** shows the two-sample SPL comparison, and both samples are closely matched.

For the remaining series tests, I used the Listen AmpConnect ISC analyzer and the 0.25″ SCM microphone to measure distortion and generate time-frequency plots. For the distortion measurement, I mounted the ND4015BE/XR2064 combination with the same baffle I used for the frequency response measurements. I used a pink noise stimulus to set the SPL to 104 dB at 1 m (1.93 V). I placed the Listen microphone 10 cm from the horn's mouth to measure. **Figure 24** shows the distortion curves. Then, I used SoundCheck to get a 2.83-V/1-m impulse response and imported the data into Listen's SoundMap time-frequency software. **Figure 25** shows the resulting CSD waterfall plot. **Figure 26** shows the short-time Fourier transform (STFT) plot.

This is an amazing new flagship compression driver for 18 Sound. With a $2,258 list price, I suspect this compression driver will find its way into very high-end theater speakers and PA systems, where detail and timber at high volume levels is essential.

Beryllium has an outstanding sound quality and excels at detail and definition, so making a compression driver diaphragm from this material has been highly successful (e.g., the JBL 435Be or the TAD TD-1401). For more information, visit www.eighteensound.com. ***VC***

Submit Samples to Test Bench

Test Bench is an open forum for OEM driver manufacturers in the industry. All OEMs are invited to submit samples to *Voice Coil* for inclusion in the Test Bench column.

Driver samples can include any sector of the loudspeaker market, including transducers for home audio, car audio, pro sound, multimedia, or musical instrument applications. Contact *Voice Coil* Editor Vance Dickason to discuss which drivers are being submitted.

All samples must include any published data on the product, patent information, or any special information to explain the functioning of the transducer. Include details on the materials used to construct the transducer (e.g., cone material, voice coil former material, and voice coil wire type). For woofers and midrange drivers, include the voice coil height, gap height, RMS power handling, and physically measured Mmd (complete cone assembly, including the cone, surround, spider, and voice coil with 50% of the spider, surround, and lead wires removed). Samples should be sent in pairs to:

Vance Dickason Consulting
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