Test Bench

The New W4-2315 Home Audio 4.5" Coax Driver from TB Speaker

By Vance Dickason

This small diameter 4.5" W4-2315 coincident coax transducer from Tang Band (TB) Speaker, is a great new example of this genre (**Photos 1–3**).

Buyers are currently seeing several three-way speakers on the market using coaxial mid/hi sections, but primarily in the studio monitor market more than in home audio speakers. Examples of three-way studio monitors using coincident coaxial for the midrange and tweeter are Genelec's The Ones product line (Genelec 8331A, 8341A, 8351A, and 8361A); Antelope Audio's Atlas i8; Ex Machina's Pulsar MKII, Ganymede, Quasar MKII, and Arcturus; and Kali Audio's IN-8 V2 and IN 5. These speakers all incorporate small diameter coincident coax drivers, such as the TB Speakers W4-2315.

In terms of features, the W4-2315 woofer is built on a proprietary six-spoke injection molded two-piece polymer plastic frame with an injection-molded aluminum trim plate attached. Cooling for this driver is provided by the substantial motor mass as part of the underhung voice coil configuration, plus the frame is totally open below the spider (damper) mounting shelf, which allows substantial air flow past the voice coil over the front plate.

The woofer cone assembly comprises a very shallow curved-profile bamboo fiber paper cone, which includes a flat copper center ring. This copper ring is downturned toward the center and the assembly also includes a plastic collar for the voice coil/cone joint. Both the center copper trim piece and the plastic collar provide a very stiff inside diameter of the bamboo fiber cone.

This complex cone assembly is suspended by an articulated NBR (CBR) surround. While the surround is cosmetically attractive, it also resists non-uniform "buckling" as the surround stretches. Remaining compliance is provided by 3.25" diameter flat cloth spider (damper) with the tinsel leads attached 180° on opposite sides of the driver. The cone assembly is driven with a 32mm (1.26") diameter voice coil wound with round copper wire on an aluminum former.

The motor assembly is made up of a 65mm×5mm neodymium ring magnet sandwiched between a 12mm thick, milled front plate and milled back plate that form the underhung 12mm gap for the 6.4mm long voice coil, which yields a 2.8mm Xmax. The sensitivity for the woofer is 88dB 1W/1m with a 30W power handling rating.

The high-frequency device is mounted on a pole inside the long voice coil former that extends about 1" from the top of the front plate of the motor structure. The tweeter is comprised of a 19mm diameter aluminum inverted dome diaphragm suspended by a cloth surround. Powered by a neodymium slug, the tweeter motor incorporates a resonant back chamber design that gives the tweeter a 1.6kHz to 40kHz operating range, with is impressive for a 0.75" diameter tweeter.

Terminals for the 19mm aluminum/magnesium tweeter are located on the injection-molded frame adjacent to the spider mounting shelf. Applications for the W4-2315 are primarily as a high-performance small two-way speaker or as the midrange/tweeter in a three-way home or studio monitor design.

Photo 1: TB Speaker W4-2315 coax front and rear photo.

Photo 2: This is a close-up view of the TB Speaker W4-2315 woofer cone and tweeter dome.

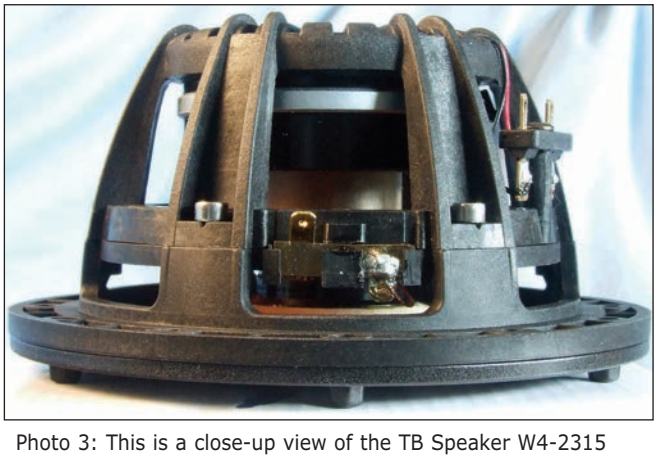

Photo 3: This is a close-up view of the TB Speaker W4-2315 motor structure.

Testing commenced with the woofer section of the TB Speaker's W4-2315 coincident coax driver using the LinearX LMS and Physical Lab IMP Box (the same type voltage/current fixture as a LinearX VI Box) to create both voltage and admittance (current) curves.

The driver was clamped to a rigid test fixture in free air at 0.3V, 1V, 3V, 6V, 10V, and 15V with a gradually increasing oscillator on time between sweeps to simulate the actual thermal temperature increase over time allowing the voice coil to reach the third time constant. The 15V curves were still linear enough to get a sufficient curve fit and were included in the testing, which is definitely impressive for a 4.5" woofer.

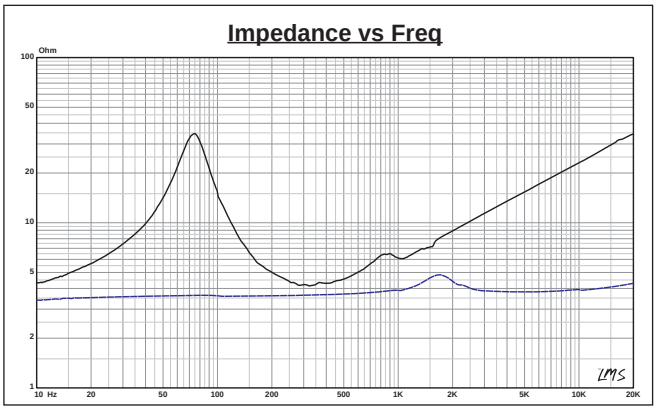

Figure 1: TB Speaker W4-2315 free-air impedance plot (solid black curve=woofer, dashed blue curve=tweeter).

Following my established protocol for Test Bench testing, I no longer incorporate a single added mass measurement and instead use the company's supplied Mmd data (7.76

	TSL Model		LTD Model		Factory
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	72.4Hz	69.6Hz	70.7Hz	65.4Hz	65Hz
R_{EVC}	3.60	3.62	3.60	3.62	3.60
Sd cm^2	70.9	70.9	70.9	70.9	69.0
Q_{MS}	3.19	3.44	3.41	3.51	3.68
Q_{ES}	0.38	0.35	0.38	0.35	0.31
Q_{TS}	0.34	0.32	0.35	0.32	0.29
V_{AS}	4.26 ltr	4.61 ltr	4.56 ltr	5.27 ltr	4.96 ltr
SPL 2.83 V	88.2dB	88.3dB	88.0dB	88.0dB	88dB
X_{MAX}	2.8mm	2.8mm	2.8mm	2.8mm	2.8mm

Table 1: Comparison data for the TB Speakers W4-2315.

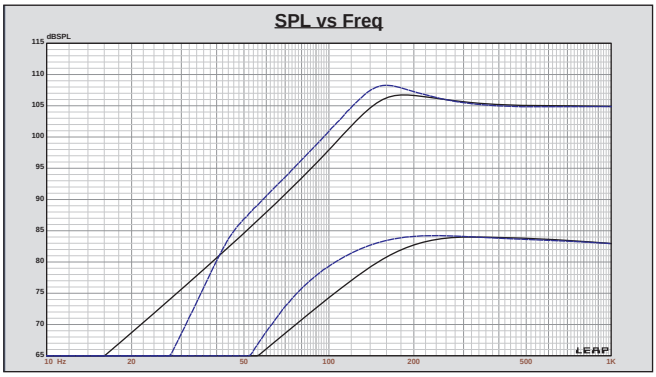

Figure 2: TB Speaker W4-2315 woofer computer box simulations (black solid= sealed @ 2.83V; blue dash= vented @ 2.83V; black solid= sealed @ 28.75V; blue dash= vented @ 28.75V).

grams for the TB Speaker W4-2315). The collected data for the W4-2315 included the 12 550-point (0.3V-15V) voltage and current sine wave sweeps for each TB sample, which were post-processed and the voltage curves divided by the current curves to generate impedance curves, with the phase derived using the highly accurate LinearX phase calculation method. The data, along with the accompanying voltage curves, was imported to the LEAP 5 Enclosure Shop software. **Figure 1** shows the woofer 1V free-air impedance

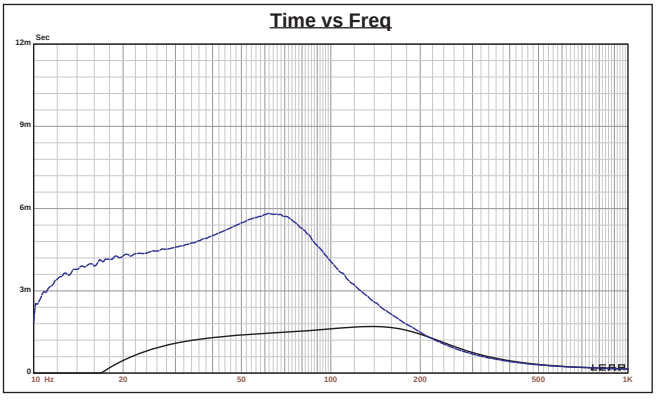

Figure 3: Group delay curves for the 2.83V curves shown in Figure 2.

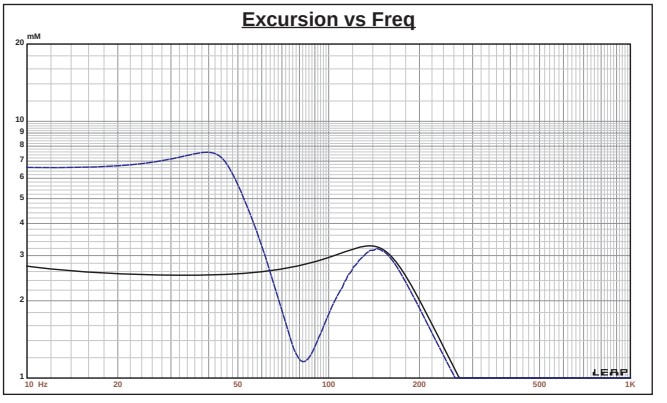

Figure 4: Cone excursion curves for the 28.75V curves shown in Figure 2.

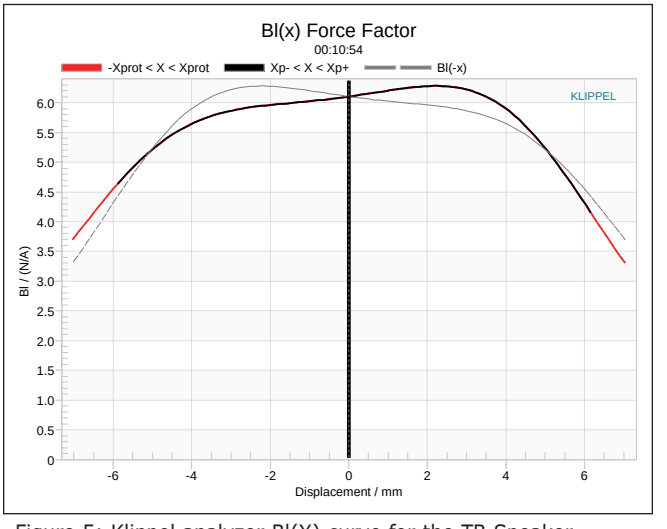

Figure 5: Klippel analyzer Bl(X) curve for the TB Speaker W4-2315 woofer.

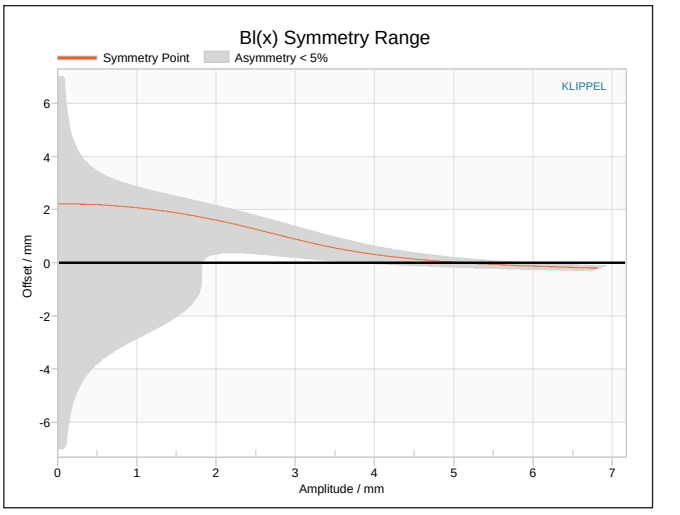

Figure 6: Klippel analyzer Bl symmetry range curve for the TB Speaker W4-2315 woofer.

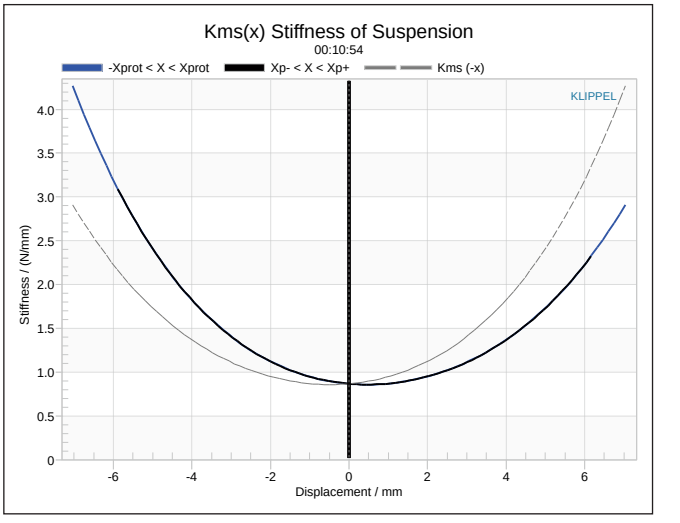

Figure 7: Klippel analyzer mechanical stiffness of suspension Kms(X) curve for the TB Speaker W4-2315 woofer.

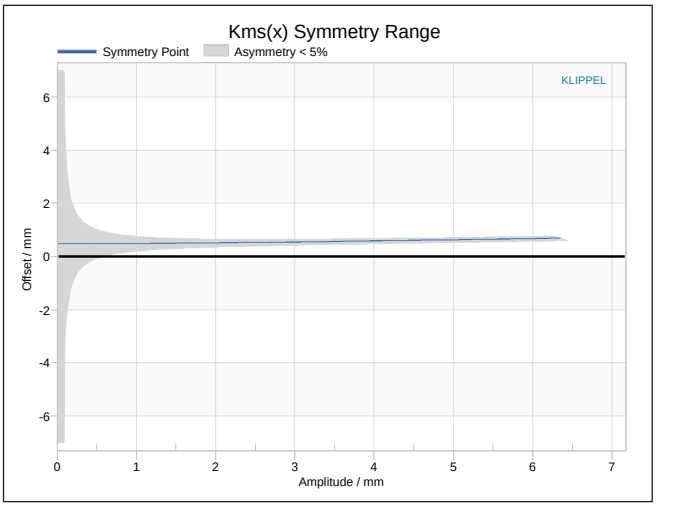

Figure 8: Klippel analyzer Kms symmetry range curve for the TB Speaker W4-2315 woofer.

curve, along with the 19mm tweeter free-air impedance curve. **Table 1** compares the LEAP 5 LTD/TSL TSP data and factory parameters for both TB Speakers W4-2315.

Parameter measurement results for the TB Speaker W4-2315 correlated well with the TB Speaker's factory published data. Given the nicely correlated results, I proceeded to set up two computer enclosure simulations using the LEAP LTD parameters for Sample 1—a Butterworth alignment sealed box with a 77in^3 volume and 50% fiberglass fill material, and a vented QB3 alignment with a 119in^3 box volume tuned to 81Hz, and with 15% fiberglass fill material.

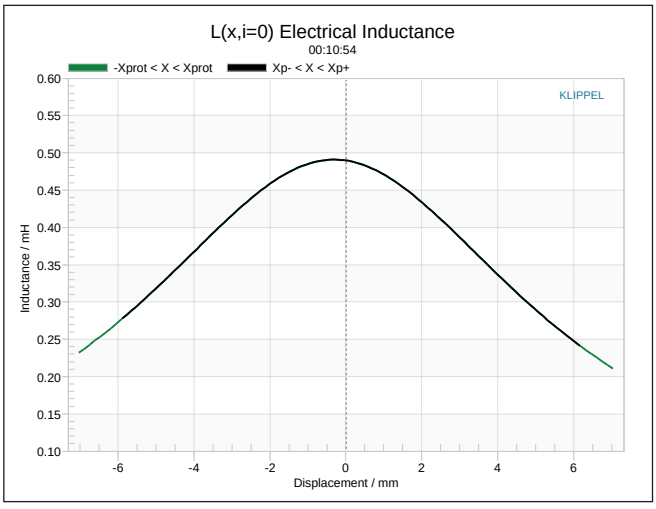

Figure 9: Klippel analyzer L(X) curve for the TB Speaker W4-2315 woofer.

Figure 2 displays the results for the TB W4-2315 woofer simulated in the sealed and vented enclosures at 2.83V and at a voltage level sufficiently high enough to increase cone excursion to Xmax+15% (3.2mm for the W4-2315). This produced a F3 frequency of 161Hz (-6dB=128Hz) for the closed enclosure with a Qtc=0.66, and a –3dB=118Hz (-6dB=93Hz) for the QB3 vented box. Maximum linear excursion (Xmax+15%) resulted in 107dB at 28.75V for the sealed box simulation and 108B for the same 28.75V input for the vented enclosure. **Figure 3** shows the 2.83V group delay curves. **Figure 4** shows the 28.75V excursion curves.

Klippel analysis for the woofer half of the W4-2315 was

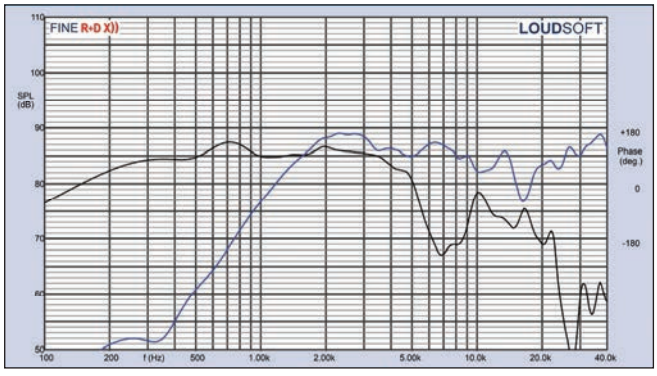

Figure 10: TB Speaker W4-2315 on-axis frequency response (black curve=woofer, blue curve=compression driver).

performed this month at Redrock Acoustics by Patrick Turnmire using the Klippel DA2 distortion analyzer. The Bl(X) curve for W4-2315 (**Figure 5**) is moderately symmetrical and reasonably broad for a small diameter 4.5" driver, but also with an obvious degree of "tilt" and coil outward offset. The Bl symmetry curve (**Figure 6**) shows 1.6mm forward offset once the graph reached a place of certainty at the 2.0mm point, decreasing to 1mm forward (coil-out) offset at the driver's physical Xmax at 2.8mm.

Figure 7 and **Figure 8** show the Kms(X) and Kms symmetry curves for the TB Speaker's W4-2315 coincident coax. The Kms stiffness of compliance curve (Figure 7) is also relatively broad and symmetrical, again for a small

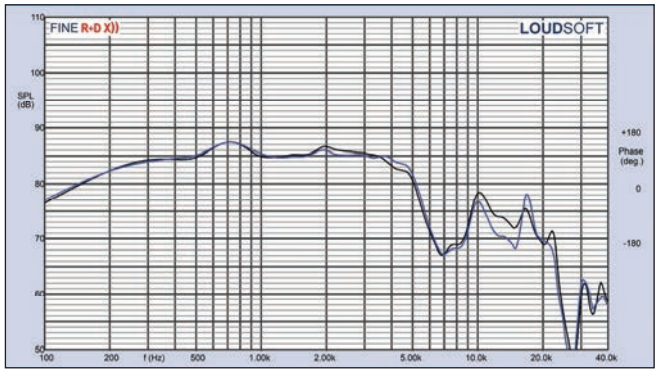

Figure 14: TB Speakers W4-2315 woofer two-sample SPL comparison.

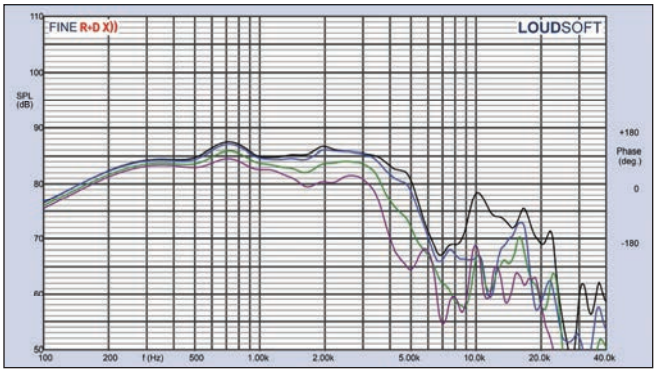

Figure 11: TB Speaker W4-2315 woofer horizontal on- and off-axis frequency response (0°=black; 15°=blue; 30°=green; 45°=purple).

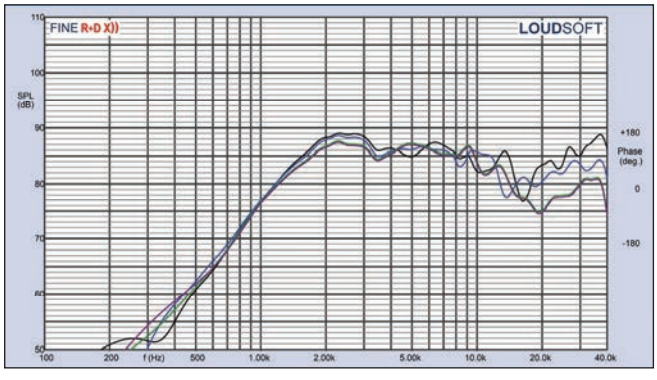

Figure 15: TB Speakers W4-2315 tweeter horizontal on- and off-axis frequency response (0°=black; 15°=blue; 30°=green; 45°=purple).

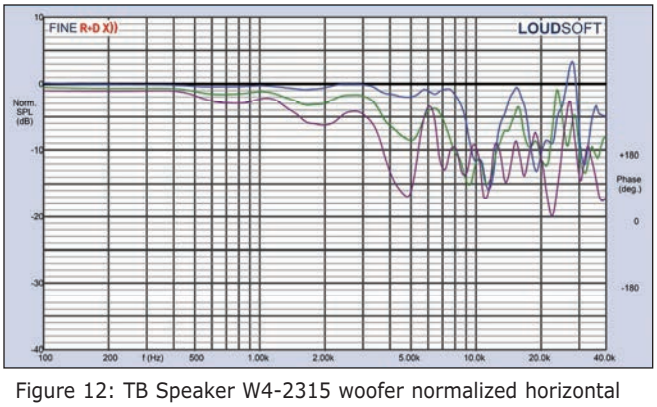

Figure 12: TB Speaker W4-2315 woofer normalized horizontal on- and off-axis frequency response (0°=black; 15°=blue; 30°=green; 45°=purple).

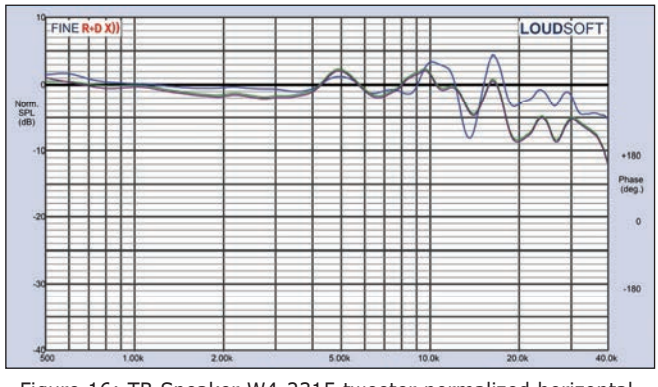

Figure 16: TB Speaker W4-2315 tweeter normalized horizontal on and off-axis frequency response (0°=black; 15°=blue; 30°=green; 45°=purple).

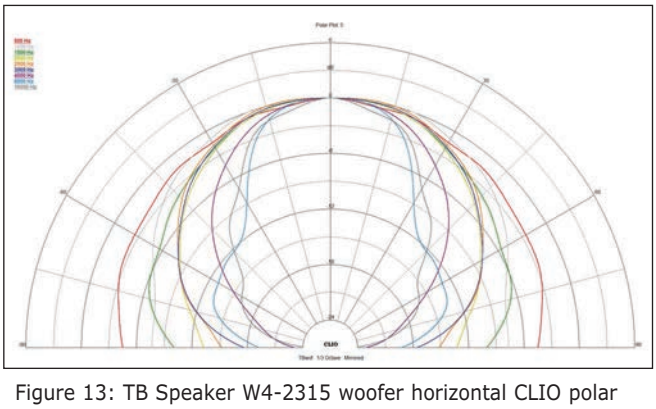

Figure 13: TB Speaker W4-2315 woofer horizontal CLIO polar plot.

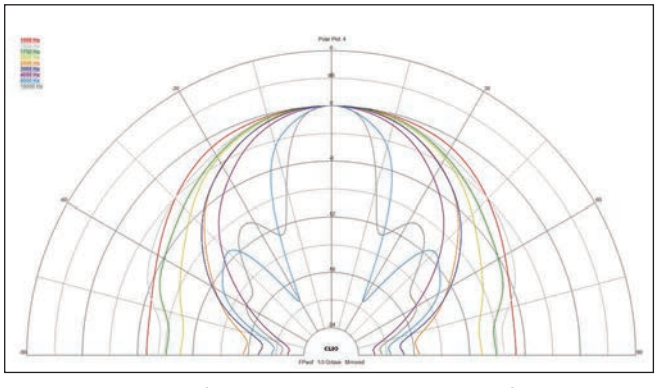

Figure 17: TB Speaker W4-2315 tweeter CLIO analyzer horizontal polar plot.

diameter woofer, and with a degree of asymmetry. The Kms symmetry range curve (Figure 8) indicates a fairly constant forward offset of 0.5mm forward offset at the 1.0mm point of reasonable certainty and increases slightly 0.65mm at the 2.8mm physical Xmax point.

Displacement limiting numbers calculated by the Klippel analyzer using the full-range woofer criteria for Bl was XBl @ 82% (Bl dropping to 82% of its maximum value) was 5.3mm (greater than the physical Xmax for the W4-2315) for the prescribed 10% distortion level. For the compliance, XC @ 75% Cms minimum was only 2.1mm, which means that for the W4-2315 woofer section of this coax driver, the compliance is the more limiting factor for getting to the 10% distortion level.

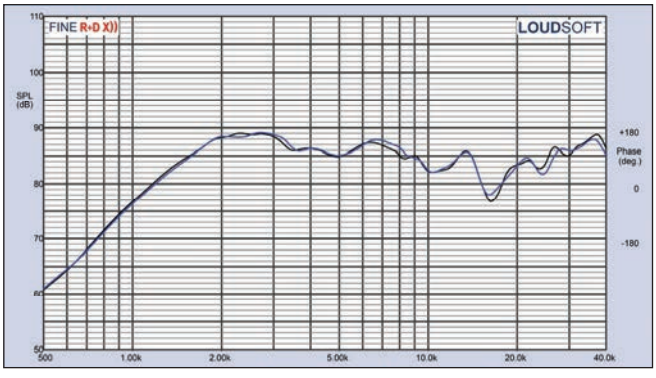

Figure 18: TB Speakers W4-2315 tweeter two-sample SPL comparison.

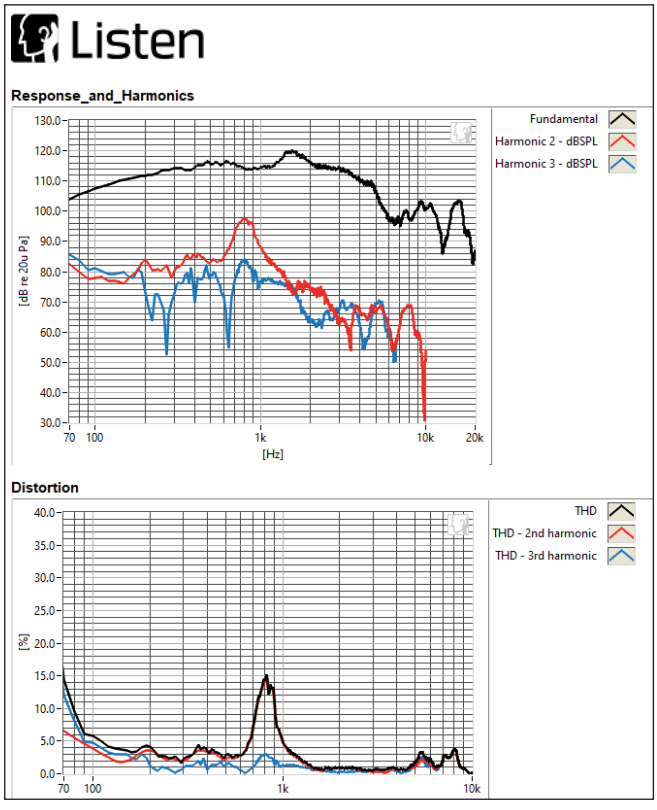

Figure 19: TB Speaker W4-2315 woofer SoundCheck distortion plots.

Figure 9 gives the inductance curves Le(X) for the W4-2315. Inductance will typically increase in the rear direction from the zero-rest position as the voice coil covers more pole area, which is not what is happening here, and is due to the neodymium underhung motor design. The maximum inductance swing for this driver from Xmax in to Xmax out is a low 0.09mH, which is good inductive performance for this neodymium underhung woofer motor.

With the Klippel analysis completed, I proceeded to mount the TB W4-2315 in an enclosure, which had a 12"x6.5" baffle filled with foam-damping material. Then, I measured both the woofer and the high-frequency driver on- and off-axis from 200Hz to 40kHz at 2V/0.5m, normalized to 2.83V/1m using the Loudsoft FINE R+D analyzer and the GRAS 46BE microphone (courtesy of Loudsoft and GRAS Sound & Vibration). **Figure 10** gives the W4-2315 woofer's on-axis response along with the tweeter's on-axis response. This response graph shows the woofer to be very well behaved and has a gently rising response ±1.5dB out to 3.7kHz where it begins a typical second-order low-pass roll-off. For the tweeter, the response is ±3.5 from 1.2kHz to 15kHz, extending to 40kHz, as advertised.

Figure 11 depicts the woofer's on- and off-axis frequency response at 0°, 15°, 30°, and 45°. The -3dB at 30° with

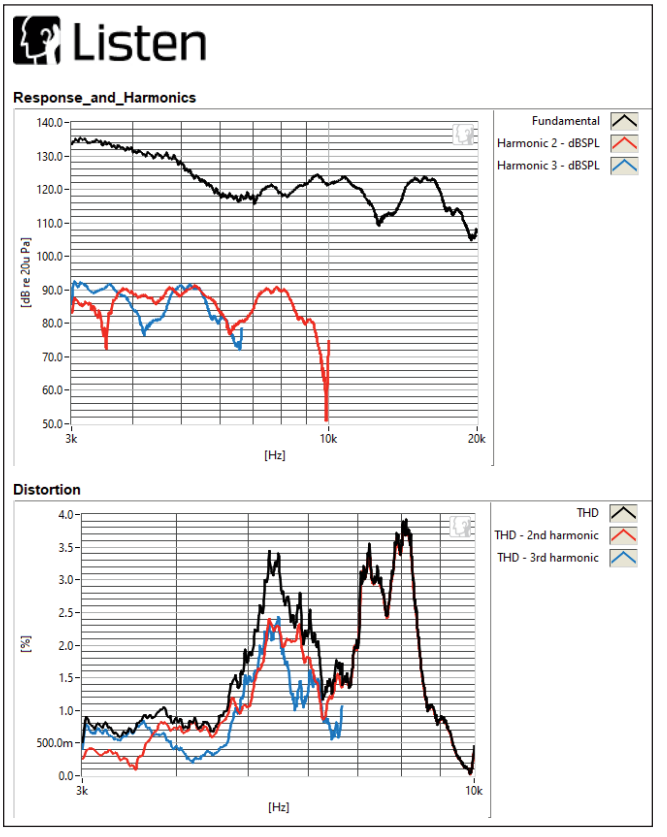

Figure 20: TB Speaker W4-2315 tweeter SoundCheck distortion plots.

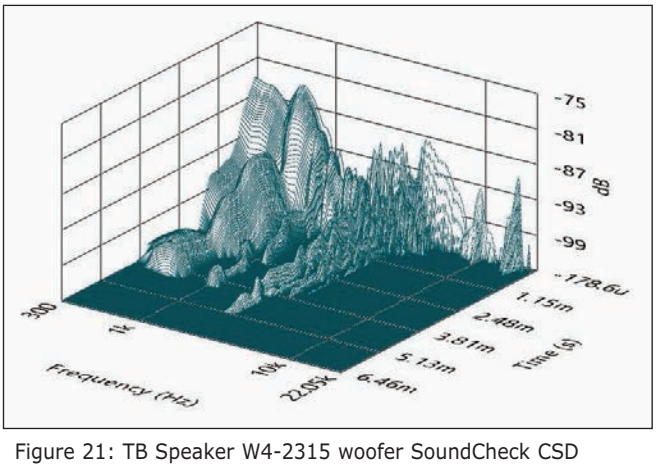

Figure 21: TB Speaker W4-2315 woofer SoundCheck CSD waterfall plot.

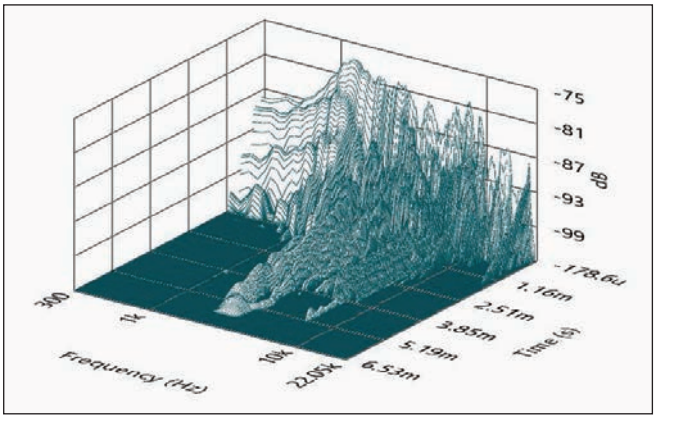

Figure 22: TB Speaker W4-2315 tweeter SoundCheck CSD waterfall plot.

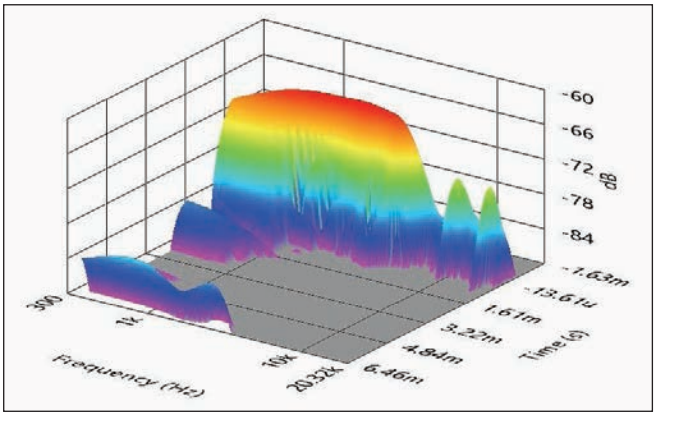

Figure 23: TB Speaker W4-2315 woofer SoundCheck Wigner-Ville plot.

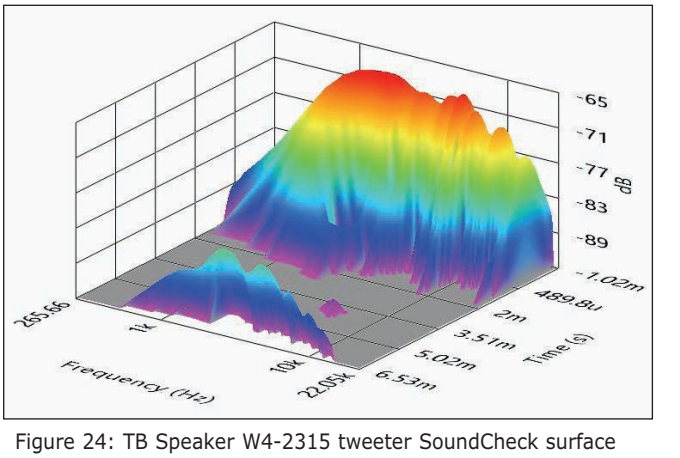

Figure 24: TB Speaker W4-2315 tweeter SoundCheck surface map Short Time Fourier Transform (STFT) plot.

respect to the on-axis curve occurs between 1.8kHz to 2kHz, which puts it at the low-frequency performance range of the tweeter. **Figure 12** gives the normalized version of Figure 11. **Figure 13** depicts the CLIO 180° polar plot (in 10° increments). And last, **Figure 14** gives the two-sample SPL comparisons for the TB W4-2315 woofers, both samples matched within 0.5dB to 1.0dB within the woofers operating range.

For the 19mm aluminum/magnesium tweeter, **Figure 15** gives the on- and off-axis horizontal frequency response out to 45°, with the normalized version shown in **Figure 16**. **Figure 17** shows the CLIO 180° polar plot (processed in 10° increments). **Figure 18** depicts the two-sample SPL comparison for the compression driver half of the TB W4-2315 coax, which is within 0.5dB to 1dB out to 20kHz.

The last batch of test procedures was performed using the Listen AmpConnect analyzer and SC-1 microphone (courtesy of Listen, Inc.) along with the SoundCheck software to measure distortion and generate time-frequency plots. Setting up for the distortion measurement consisted of mounting the driver rigidly in free air, with the voltage level determined to raise SPL to 94dB for the TB W4-2315 woofer/tweeter at 1m using a pink noise stimulus (SoundCheck has a software generator and SPL meter as two of its utilities). Then, I measured the distortion with the Listen microphone placed 10cm from the woofer dust cap and tweeter horn. This produced the distortion curves shown in **Figure 19** for the woofer (6.2V), and the distortion curves shown in **Figure 20** for the tweeter dome (1.43V).

With the distortion testing completed, I set up SoundCheck to produce a 2.83V/1m impulse response for both the woofer and compression driver and imported the data into Listen's SoundMap Time/Frequency software. The resulting CSD waterfall plots are given in **Figure 21** for the TB W4-2315 woofer and in **Figure 22** for the dome tweeter. For the final SoundMap graphic output, **Figure 23** gives the woofer's Wigner-Ville logarithmic surface map (chosen for its better low-frequency performance), and **Figure 24** displays the Short Time Fourier Transform (STFT) plot for the compression driver.

Looking over all the data presented, the TB Speaker W4-2315 is a very well designed and configured coincident coax transducer. TB Speakers' products are consistently well engineered with a combination of innovation and creativity, with the W4-2315 representing another good example of the company's craft. For more information, visit the TB Speaker website at www.tb-speaker.com. ***VC***

Submit Samples to Test Bench

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

Send samples in pairs and addressed to:

Vance Dickason Consulting
4330 Imperial Drive
West Linn, OR 97068
(503-557-0427) | vdconsult@comcast.net

All samples must include any published data on the product, patent information, or any special information necessary to explain the functioning of the transducer.