Test Bench

Wavecor's New WF211PA01 8.25" PA Woofer

By Vance Dickason

Wavecor, the China-based OEM that partnered with former Vifa engineers, has released its second pro audio driver, the new WF211PA01/02 (4Ω and 8Ω versions) 8.25" woofer. Until 2018, Wavecor had been known for its high-end home hi-fi drivers. However, the company decided at that time to expand its coverage in the loudspeaker market by introducing a new OEM pro sound PA woofer, the WF259PA01 10" woofer explicated in the *Voice Coil* February issue. The WF211PA01 is basically an 8.25" version of the WF259PA01 10" pro sound wooferand designed much like Wavecor's high-performance home audio woofers.

Wavecor's WF211PA01 (**Photo 1**) is available in both 4Ω and 8Ω versions. This new driver has a generous feature set that includes a proprietary four double-spoke cast-aluminum frame that is substantially open below the spider mounting shelf due to the four 48mm x 18mm parallelogram-shaped screened vents. Other features include a very stiff flat black coated curvilinear paper cone, further stiffened by a 3.0" convex black poly dust cap. Suspension is provided by a low-loss (high Qm) coated three-roll cloth surround plus a 5" diameter black flat Conex spider (damper).

All this is driven by a 64mm diameter (2.5") voice coil wound with round wire on a vented black fiber glass non-conducting former. The motor structure powering the cone assembly utilizes a single 26mm thick, 155mm diameter ferrite magnet sandwiched between a black-plated 6mm thick front plate and a black-plated and shaped T-yoke that has 18mm diameter pole vent that is flared at both ends to suppress vent noise.

Photo 1: The new WF211PA01 8.25" PA woofer is Wavecor's second pro audio driver.

As part of Wavecor's Balanced Drive motor format, the WF211PA01 further incorporates an aluminum shorting ring (Faraday shield) that reduces distortion caused by eddy currents as well as a shaped, extended pole piece. Last the braided voice coil lead wires terminate to a pair of gold-plated terminals. Continuous rated power handling (IEC-268-5 with no additional filtering) is 170W (300W short term). Intended applications include both PA systems and studio monitors, or any place where high sensitivity and high-power handling transducers are required.

I began characterizing the WF211PA01 8.25" pro sound woofer using the LinearX LMS analyzer and VIBox to measure both voltage and admittance (current). Sweeps were generated in free air at 0.3V, 1V, 3V, 6V, 10V, and 15V, remaining sufficiently linear for LEAP 5 to obtain a sufficient curve fit for the 15V sweeps. The measured Mmd that was provided by Wavecor (an actual physical cone assembly measurement with 50% of the surround and spider removed) was used rather than a single 1V added (delta) mass measurement.

The 12 stepped sine wave sweeps for each woofer were further processed with the voltage curves divided by the current curves to produce impedance curves. Phase curves were generated using the LEAP phase calculation routine, after which the impedance magnitude and phase curves plus the associated voltage curves were then copy/pasted into the LEAP 5 Enclosure Shop software's Guide Curve

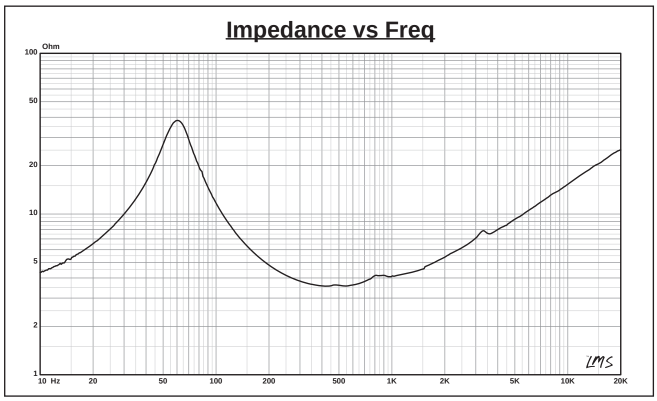


Figure 1: Wavecor WF211PA01 pro sound woofer 1V free-air impedance plot.

	TSL Model		LTD Model		Factory
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	59.0Hz	58.6Hz	56.6Hz	53.2Hz	59Hz
R_{EVC}	3.09	3.11	3.09	3.11	3.1
Sd cm^2	219.0	219.0	219.0	219.0	214
Q_{MS}	2.93	2.60	2.92	2.53	5.8
Q_{ES}	0.25	0.26	0.28	0.25	0.26
Q_{TS}	0.23	0.23	0.25	0.23	0.25
V_{AS}	18.9 ltr	19.1 ltr	20.7 ltr	23.4 ltr	18.2 ltr
SPL 2.83 V	93.7dB	93.7dB	93.1dB	93.3dB	96.5dB
X_{MAX}	2mm	2mm	2mm	2mm	2mm

Table 1: Comparison data for Wavecor's WF211PA01 8.25" PA woofer.

library. This data was then used to calculate parameters utilizing the LEAP 5 LTD transducer model. I also generated LEAP 4 TSL model parameters using the 1V free air that can also be compared with the manufacturer's data. Figure 1 shows the WF211PA01 1V free-air impedance plot. Table 1 compares the LEAP 5 LTD and LEAP 4 TSL Thiele-Small (T-S) parameter sets for the two Wavecor WF211PA01 driver samples along with the Wavecor factory data.

From the comparative data shown in Table 1 for the 8″ Wavecor 4Ω PA woofer, you can see that all four parameter sets for the two samples were reasonably similar and correlated well with the factory data, with the two deviations being Qms and SPL. My Qms data looks low for a non-conducting former, but the Klippel LMP TSP from the numbers was about the same with Qms=3.24. Wavecor also uses the 2.83V/1m calculated from TSP, so I'm not certain why my numbers are 3dB lower, unless this is a misprint.

However, as always, I followed my normal protocol for Test Bench testing, and used the Sample 1 LEAP 5 LTD parameters and set up two computer enclosure simulations—one in a 0.3ft^3 QB3 vented enclosure with 15% fill material (fiberglass) tuned to 75Hz; and for the second example, a 0.5 ft^3 Extended Bass Shelf (EBS) ported box also with 15% fill material and tuned to 58Hz.

Figure 2 gives the results for the Wavecor WF211PA01 in the smaller and larger vented enclosures at 2.83V and at a voltage level sufficiently high enough to increase cone

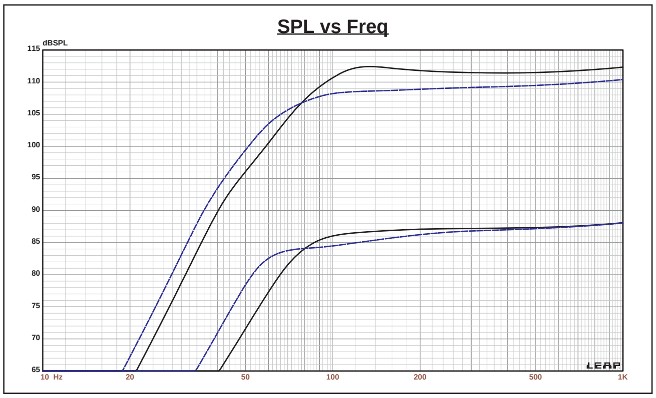


Figure 2: Wavecor WF211PA01 computer box simulations (black solid= vented 1 @ 2.83V; blue dash= vented 2 @ 2.83V; black solid=vented 1 @ 28.5V; blue dash= vented 2 @ 26.25V).

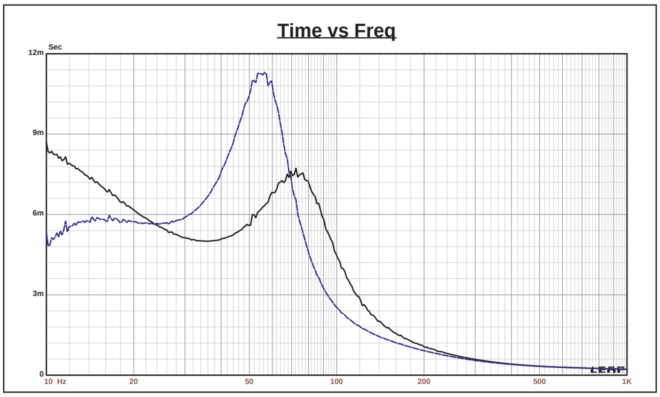


Figure 3: Group delay curves for the 2.83V curves shown in Figure 2.

excursion to Xmax+15% (2.3mm for WF211PA01). This resulted in a F3 of 76Hz (-6dB=66Hz) for the QB3 vented enclosure and a -3dB for the larger vented simulation of 55Hz (-6dB=49Hz). Increasing the voltage input to the simulations until the approximate Xmax +15% maximum linear cone excursion point was reached resulted in

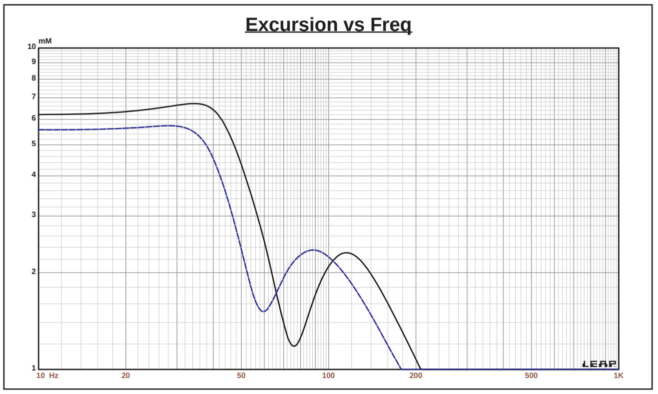


Figure 4: Cone excursion curves for the 28.5/26.25V curves shown in Figure 2.

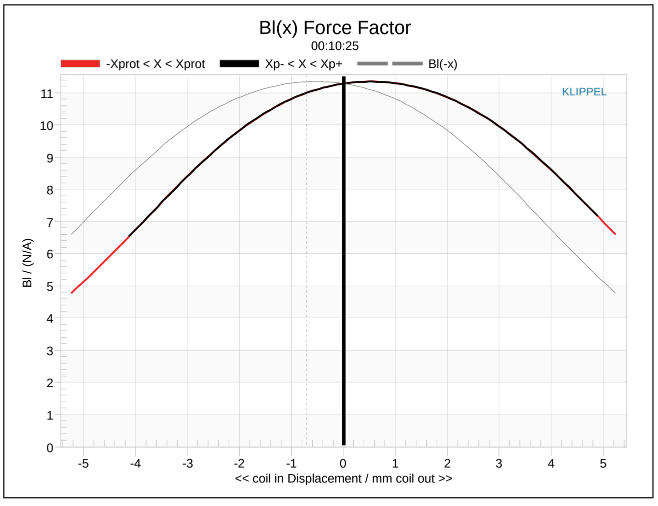


Figure 5: Klippel Analyzer Bl (X) curve for the Wavecor WF211PA01.

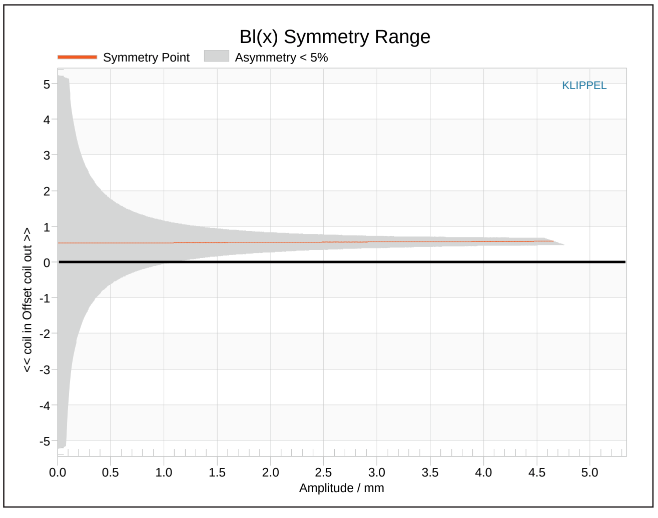


Figure 6: Klippel Analyzer Bl symmetry range curve for the Wavecor WF211PA01.

112.5dB at 28.5V for the smaller enclosure simulation and 109dB with 26.25V input level for the larger box. **Figure 3** shows the 2.83V group delay curves and **Figure 4** shows the 28.5/26.25V excursion curves.

Klippel analysis for the Wavecor 8.25" pro sound woofer—performed by Patrick Turnmire, Redrock Acoustics—produced the Klippel data graphs given in **Figures 5-8**. (Our analyzer is provided courtesy of Klippel GmbH. If you do not own a Klippel analyzer and would like to generate this type of data, Redrock Acoustics can provide Klippel analysis of most any driver for a nominal fee. Visit www.redrockacoustics.com for more information.)

The Bl(X) curve for WF211PA01 (Figure 5) is moderately broad and mostly symmetrical typical (with a small amount of offset) of a driver with a relatively low Xmax. Looking at the Bl symmetry curve (Figure 6) shows 0.54mm Bl coil-out (forward) offset once you reach an area of reasonable certainty (1.5mm), staying about the same (0.55mm) at the physical 2mm Xmax position, and decreasing beyond that point, so a moderate amount of offset for this short of an Xmax.

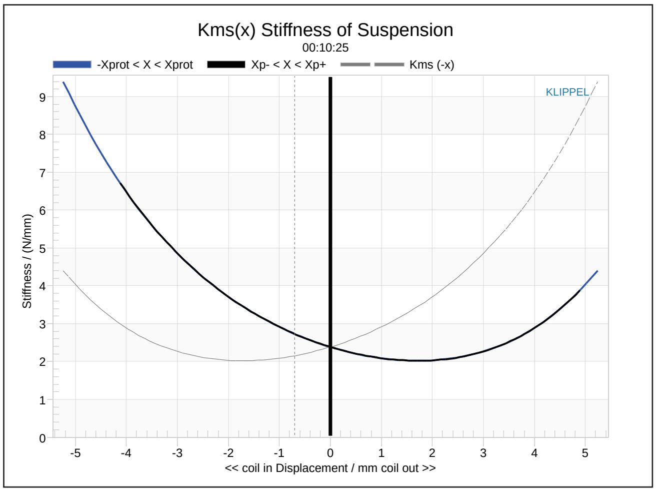


Figure 7: Klippel Analyzer mechanical stiffness of suspension Kms(X) curve for the Wavecor WF211PA01.

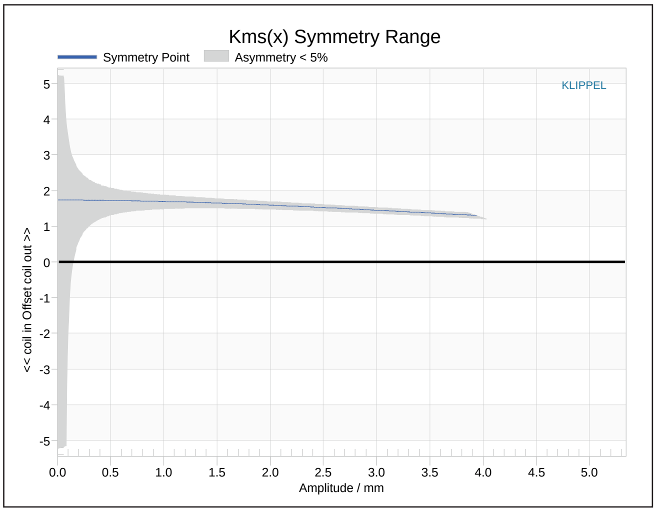


Figure 8: Klippel Analyzer Kms symmetry range curve for the Wavecor WF211PA01.

Figure 7 and Figure 8 show the Kms(X) and Kms symmetry curves for the Wavecor woofer. The Kms stiffness of compliance curve (Figure 7) is also moderately symmetrical, but with more offset. The Kms symmetry range curve (Figure 8) exhibits a minor 1.7mm coil-out (forward) offset at a region of high certainty (0.5mm) and decreases slightly to 1.58mm by 2mm physical Xmax position.

Displacement limiting numbers calculated by the Klippel analyzer for the WF211PA01 using the 10% distortion criteria for Bl was XBl @ 82% (Bl dropping to 82% of its maximum value) equal to 2.4mm, just slightly above the Xmax number. For the compliance, XC @ 75% Cms minimum was 1.7mm, which means that for the Wavecor pro sound woofer, the compliance is the more limiting factor for getting to the 10% distortion level. Using the 20% distortion criteria (Bl dropping 70% and compliance dropping 50%), the numbers are both above Xmax with XBl=3.3mm and XC=2.9mm.

Figure 9 gives the inductance curve Le(X) for this transducer. Motor inductance will typically increase in the rear direction from the zero-rest position as the voice coil covers more of pole, however that doesn't happen here. What we do get is lower inductance variation from full in to full out travel, which is the goal you want to achieve. The aluminum shorting ring is doing its job with inductance only varying between 0.017-0.029mH from -2mm to +2mm, which is very good inductance performance.

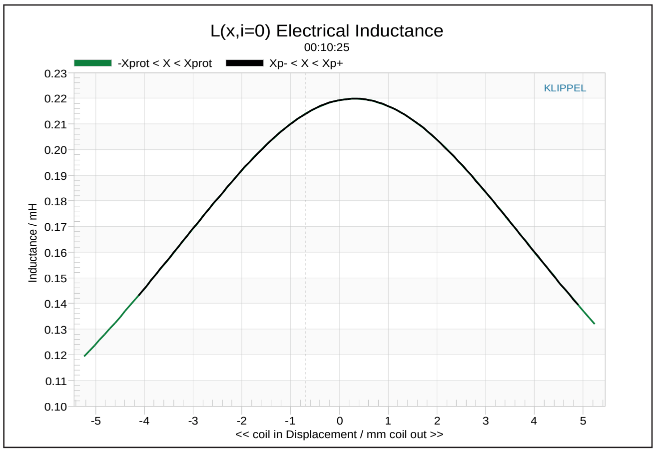


Figure 9: Klippel Analyzer Le(X) curve for the Wavecor WF211PA01.

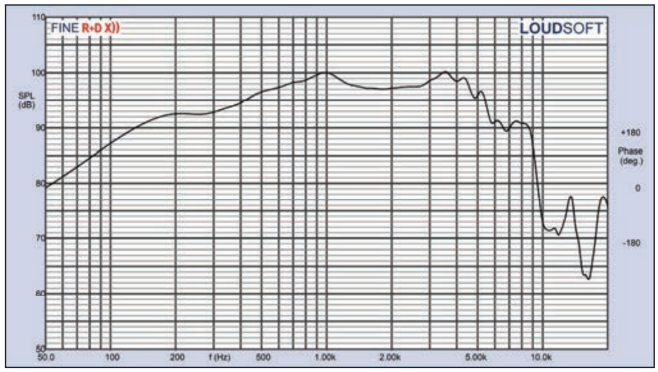
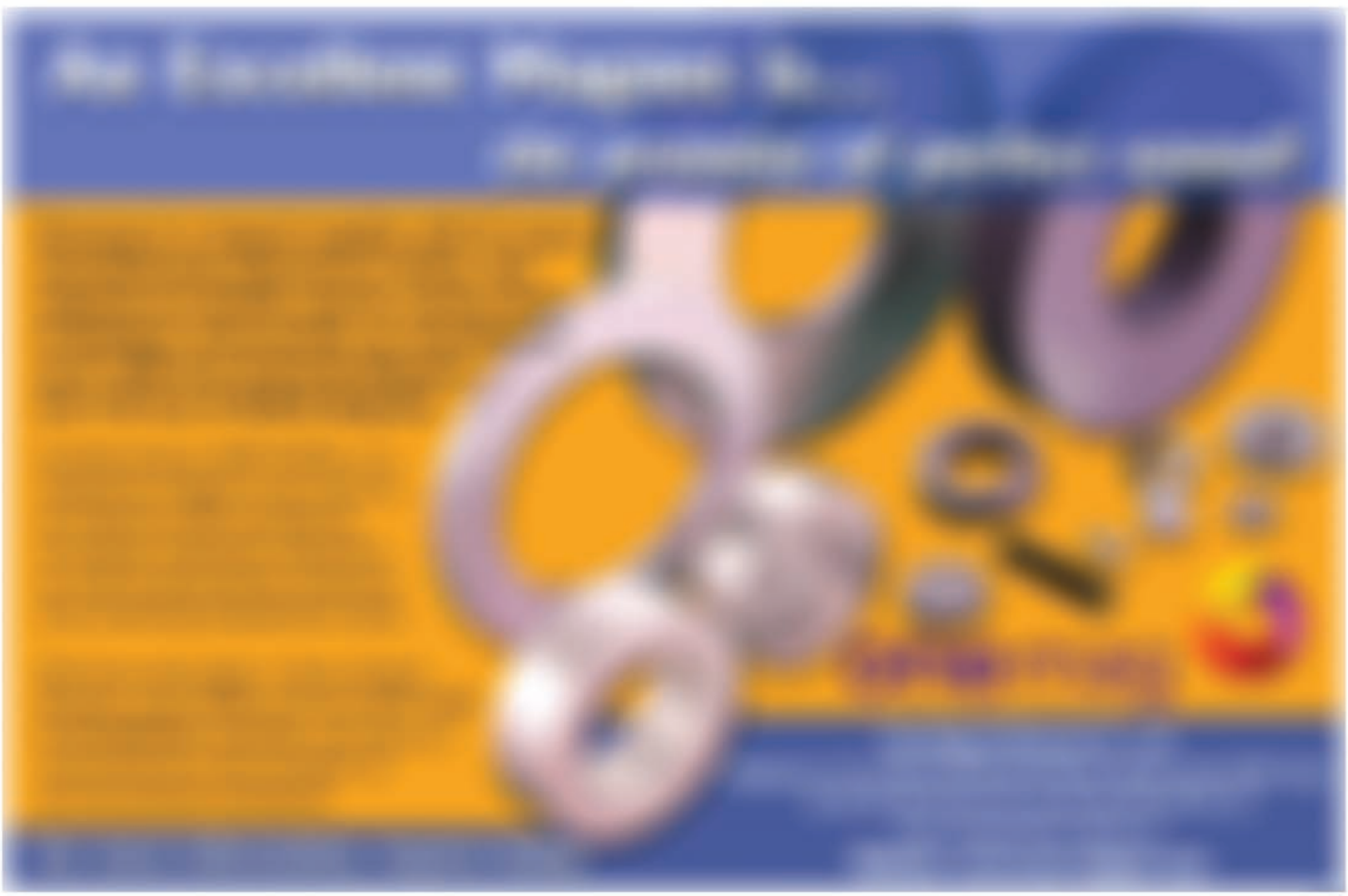


Figure 10: Wavecor WF211PA01 on-axis frequency response.



After the Klippel analysis was finished, I mounted the driver in an enclosure filled with foam-damping material, which had a 16"x11" baffle area, and proceeded to measure the Wavecor 8.25" SPL on- and off-axis using the Loudsoft FINE R+D FFT analyzer and the GRAS 46BE microphone (courtesy of Loudsoft and GRAS Sound & Vibration).

Figure 10 gives the on-axis response measured 200Hz to 20kHz at 2.83V/1m. The response is smoothly rising with no anomalies from 200Hz out to 1kHz, dropping about 3dB and back up at 4.7kHz just prior to the low-pass roll-off of the driver.

The on- and off-axis to 45° is displayed in **Figure 11**, with the normalized response shown in **Figure 12**.

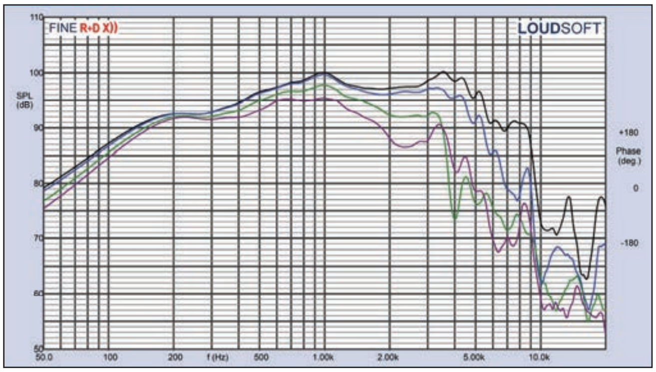


Figure 11: Wavecor WF211PA01 on- and off-axis frequency response (black solid=0°, blue dot=15°, green dash =30°, purple dash dot=45°, blue dash=60°).

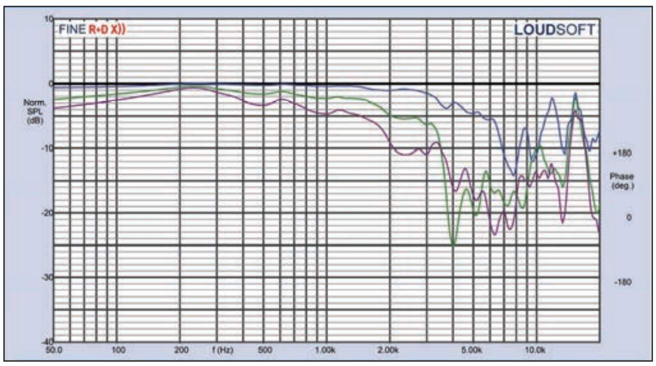


Figure 12: Wavecor WF211PA01 normalized on- and off-axis frequency response (0°=black solid; 15°=blue dot; 30°=green dash; 45°=purple dash/dot, 60°=blue dash).

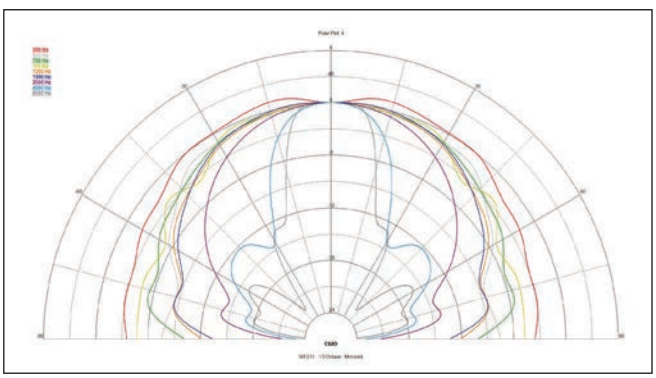


Figure 13: Wavecor WF211PA01 180° horizontal plane CLIO polar plot (in 10° increments)

Figure 13 shows the CLIO-generated polar plot. Finally, **Figure 14** gives the two-sample SPL comparison showing, as you would expect from Wavecor, the drivers to be well matched to less than 0.5dB throughout the relevant operating range up to 3kHz.

Next the Listen AudioConnect analyzer and SCM ¼" microphone was used to perform distortion and time-domain analysis. For distortion measurements, the voltage level was set with the driver rigidly mounted in free air and the voltage increased until it produced a 1m SPL of 104dB (8.1V) (104dB is my SPL standard for pro sound driver distortion measurements, and 94dB for home audio drivers). The distortion measurement was then made with the microphone placed near-field about 10cm from the dust cap. This plot is shown in **Figure 15**. As can be seen, this actually includes two plots—the top graph being the standard fundamental SPL curve with the second and third harmonic curves, and the bottom graph the second and third harmonic curves plus the THD. Interpreting the subjective value of conventional distortion curves is almost

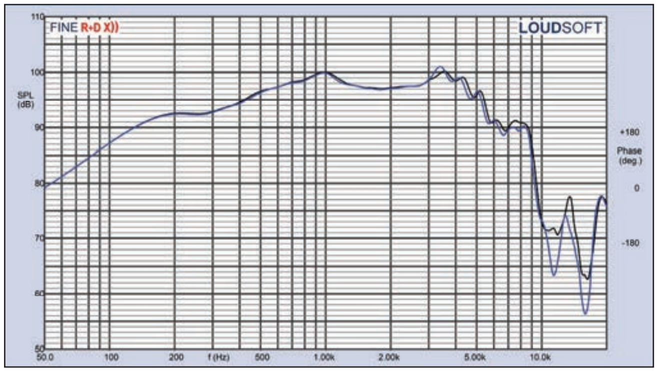


Figure 14: Wavecor WF211PA01 two-sample SPL comparison.

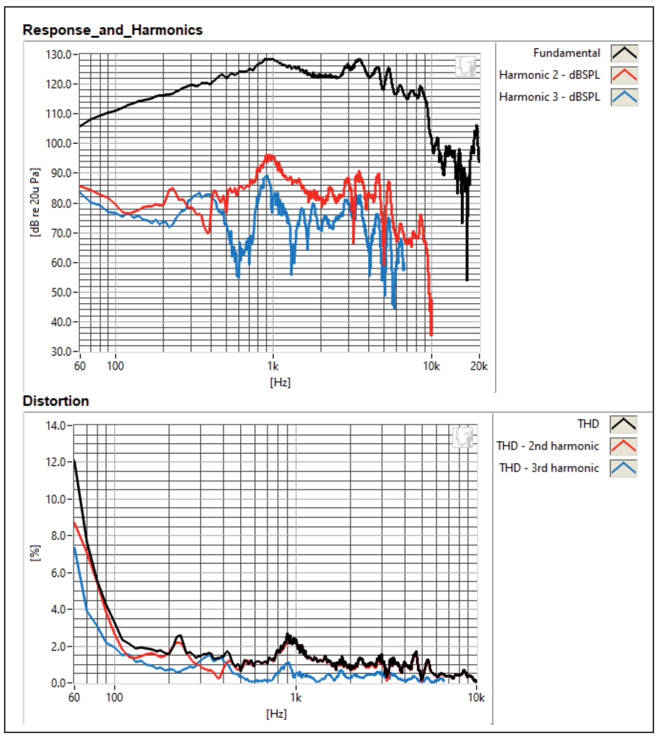


Figure 15: Wavecor WF211PA01 SoundCheck distortion plot.

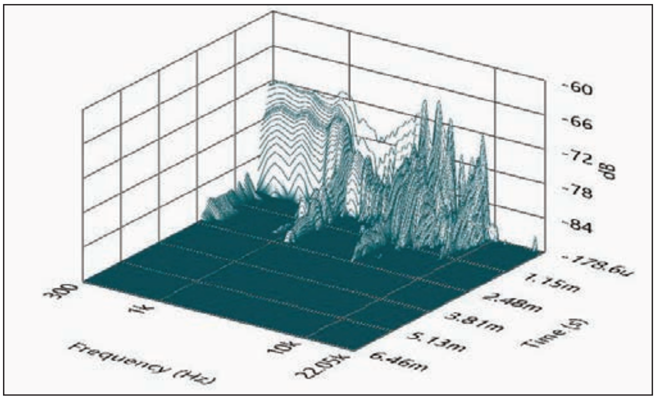


Figure 16: Wavecor WF211PA01 woofer SoundCheck CSD waterfall plot.

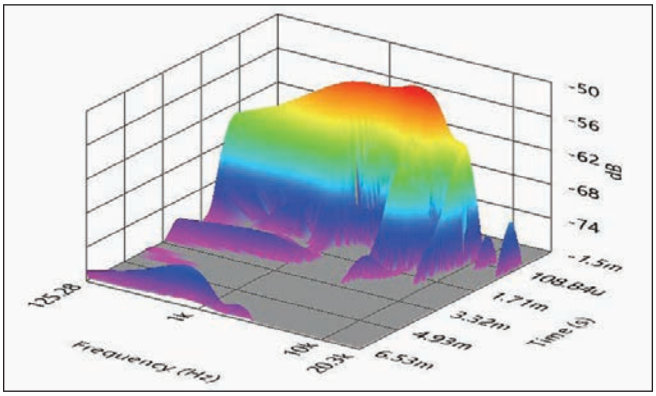


Figure 17: Wavecor WF211PA01 SoundCheck Wigner-Ville plot.

impossible; however, looking at the relationship between the second to third harmonic distortion curves is of value.

I then used SoundCheck 21 to get a 2.83V/1m impulse response for this driver (again mounted in the foam-filled enclosure with the 16"x11" baffle) and imported the data into Listen's SoundMap Time/Frequency software.

Figure 16 shows the resulting cumulative spectral decay (CSD) waterfall plot. Figure 17 shows the Wigner-Ville plot (chosen for its better low-frequency performance).

I have used Wavecor drivers (both off the shelf and with proprietary modifications) on several projects as a consultant, and have a lot of respect for this China-based company. As you can see from this month's review, the WF211PA01 8.25" pro sound woofer is another well-crafted transducer from the engineers at Wavecor, especially for a second offering for the pro sound market. For more information, visit www.wavecor.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.