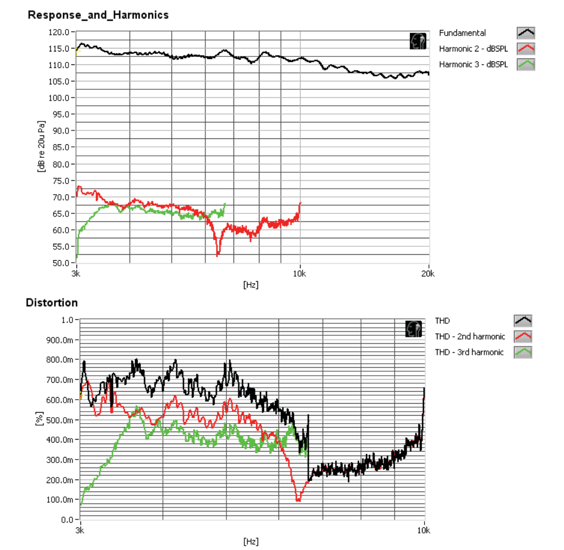
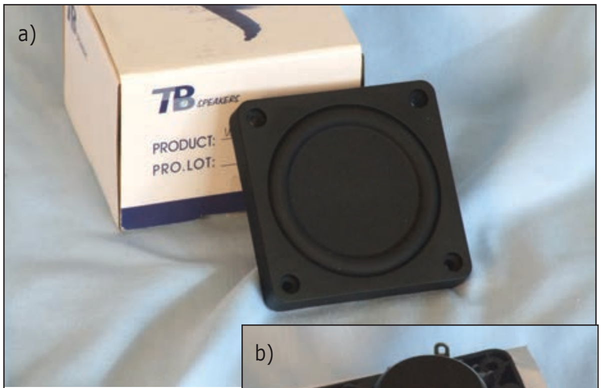


Figure 8: SEAS T29B001 SoundCheck distortion plot



a)


b)

Photo 2: Tang Band's W3-2052S 3" subwoofer, which is shown in front (a) and back (b) view, is unusual because it does not use a spider.

For high-end home audio manufacturers who want a beryllium tweeter in a no-compromise high-end product, SEAS has generated another outstanding option. For more information about the T29B001 and other high-performance drivers from SEAS, visit www.seas.no.

THE W3-2052S

I also examined the W3-2052S, a new 3" subwoofer from the Taiwan-based driver manufacturer Tang Band (aka TB Speakers). The W3-2088SOF, a 3.5" ferrite version of Tang Band's unique mini subwoofer was featured in *Voice Coil*, January 2014. As I noted with the W3-2088SOF, there is considerable market emphasis placed on table-top Wi-Fi and Bluetooth speakers (a "craze" Sonos primarily initiated). This makes Tang Band's 3" subwoofer a "hot" item.

The TB W3-2052S is built on a rather interesting injection-molded eight-spoke frame that supports a rectangular housing (see **Photo 2**). However, the W3-2052S is unusual

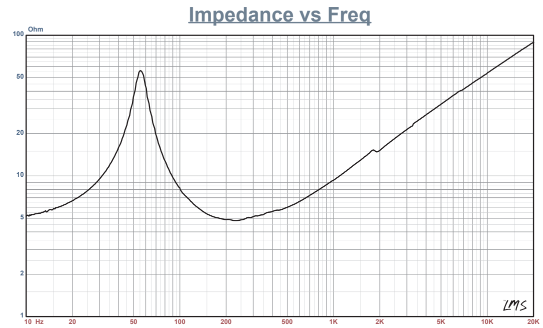


Figure 9: Tang Band W3-2088SOF woofer 1-V free-air impedance plot

because it does not use a spider. Instead, it gets all its compliance from two back-to-back mounted surrounds. The Santoprene surround is glued to a flat diaphragm. Another surround and flat diaphragm spaced about 0.25″ apart from each other are located on this rectangular structure's underside but with the surround roll in the reverse direction. The design is similar to a dual-spider configuration, which is used to cancel out odd-order non-linearity. The voice coil former is vented below the inside diaphragm and also vented between the two diaphragms.

All this is driven by a 25.4-mm diameter (1″) voice coil wound with round copper wire on a paper-reinforced vented aluminum former. The motor system powering the cone assembly utilizes a neodymium magnet and a black-coated metal return cup. Last, the braided voice coil lead wires terminate to a pair of solderable terminals mounted on opposite sides of the frame.

I began characterizing the new W3-2052S 3″ mini subwoofer with the LinearX LMS analyzer and VIBox. I generated the voltage and admittance (current) measurements in free-air at 0.3, 1, 3, 6, and 10 V. Surprisingly, as with the 3.5″ W3-2088SOF, the device remained linear enough to get a good curve fit at 10 V. (Most drivers this small do not stay linear enough to use voltage higher than 6 V).

I further processed the 10 sine wave sweeps for each woofer sample with the voltage curves divided by the current curves to produce impedance curves. I used the LEAP phase calculation routine to generate phase curves for each impedance curve. Next, I copy/pasted impedance magnitude and phase curves plus the associated voltage curves into the LEAP 5 software's Guide Curve library. I used this data to calculate parameters using the LEAP 5 LTD transducer model.

Most manufacturing Thiele-Small (T-S) parameter data is produced using either a standard transducer model or in many cases the LEAP 4 TSL model. So, I also used the 1-V free-air curves to generate LEAP 4 TSL model parameters. **Figure 9** shows the W3-2052S's 1-V free-air impedance plot. **Table 1** compares the W3-2052S's LEAP 5 LTD and LEAP 4 TSL T-S parameter sets along with the Tang Band factory data.

From **Table 1**'s comparative data, you can see all four parameter sets for the two samples were reasonably similar but showed higher Q_{MS}, Q_{ES}, and Q_{TS} values than the factory's preliminary data. Following my normal Test Bench protocol, I used the Sample 1 LEAP 5 LTD parameters and set up two

	TSL Model		**LTD Model**		**Factory**
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	55.3 Hz	54.9 Hz	52.9 Hz	52.4 Hz	50 Hz
R_{EVC} (series)	4.27	4.25	4.27	4.25	3.9
Sd	0.003	0.003	0.003	0.003	0.0032
Q_{MS}	5.79	5.54	6.06	6.07	3.39
Q_{ES}	0.47	0.45	0.53	0.54	0.38
Q_{TS}	0.44	0.42	0.49	0.5	0.34
V_{AS}	0.9 ltr	0.91 ltr	0.99 ltr	1.01 ltr	0.89 ltr
SPL 2.83 V	76.9 dB	77.1 dB	76.2 dB	76.1 dB	78 dB
X_{MAX}	5 mm	5 mm	5 mm	5 mm	5 mm

Table 1: W3-20523S subwoofer comparison data

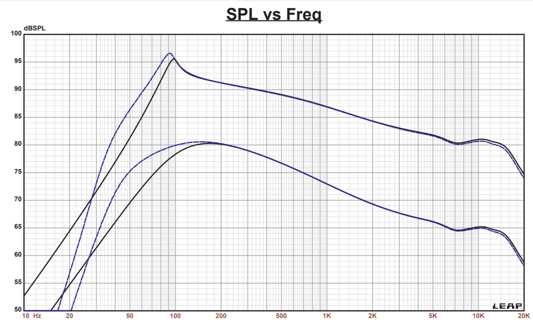


Figure 10: Tang Band W3-2052S computer box simulations (black solid = sealed at 2.83 V; blue dash = vented at 2.83 V; black solid = sealed at 15 V; blue dash = vented at 15.25 V)

computer box simulations, one in a 43-in^3 Butterworth-type sealed enclosure with 50% fill material (fiberglass) and a second vented box Chebychev/Butterworth alignment in a 79-in^3 box with 15% fill material and tuned to 63 Hz.

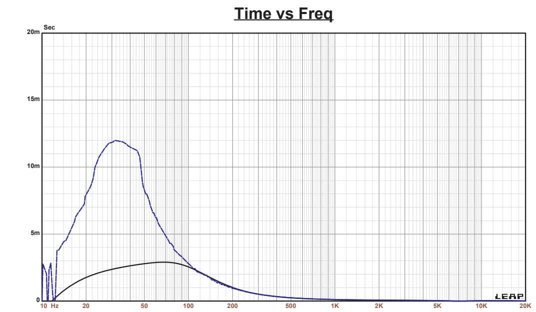


Figure 11: Group delay curves for the 2.83-V curves in Figure 13

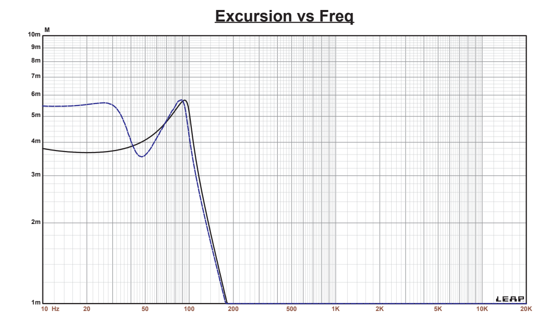


Figure 12: Cone excursion curves for the 15-to-15.25-V curves in Figure 13

Figure 10 shows the W3-2052S's results in the sealed and vented enclosures at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to 5.75 mm (X_{MAX} + 15%). This resulted in a F3 of 88 Hz (−6 dB = 68.5 Hz) with a Q_{TC} = 0.67 for the 43 in^3 closed box and a −3 dB for the Chebychev/Butterworth vented simulation of 66 Hz (−6 dB = 47 Hz).

Increasing the voltage input to the simulations until the approximate X_{MAX} + 15% maximum linear cone excursion point was reached resulted in 95.5 dB at 18.5 V for the sealed enclosure simulation and 96.5 dB with a 18.3-V input level for the larger vented box. **Figure 11** and **Figure 12** show the 2.83-V group delay curves and the 18.5-V/18.3-V excursion curves.

Klippel analysis for the W3-2052S produced the Klippel data graphs shown in **Figures 13–16**. The Test Bench analyzer is provided courtesy of Klippel GmbH and the analysis was performed by Patrick Turnmire, of Redrock Acoustics. Please note, if you do not own a Klippel analyzer and would like this type of data, Redrocks Acoustics can perform the analysis. For more information, visit www.redrockacoustics.com.

Figure 13 shows W3-2052S's Bl(X) curve, which is broad and symmetrical typical of a driver with substantial X_{MAX} (5 mm is a large X_{MAX} for a 3″ driver). The Bl symmetry curve in **Figure 14** shows virtually no offset for this driver. **Figure 15** and **Figure 16** show the W3-2052S's K_{MS}(X) and K_{MS} symmetry curves. As with the Bl curve, the K_{MS} stiffness of compliance curve (**Figure 15**) is very symmetrical, with only a minor coil-out offset. The K_{MS} symmetry range curve has a minor 0.34-mm coil-out offset at rest remaining constant to the driver's physical X_{MAX}, making the W3-2052S's Klippel data really outstanding. The W3-2052S's displacement-limiting numbers, calculated by

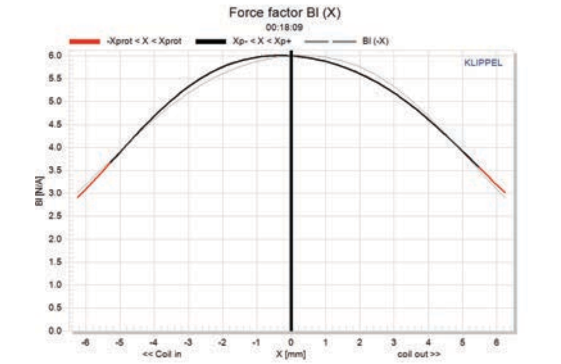


Figure 13: Klippel Analyzer Bl (X) curve for the Tang Band W3-2052S

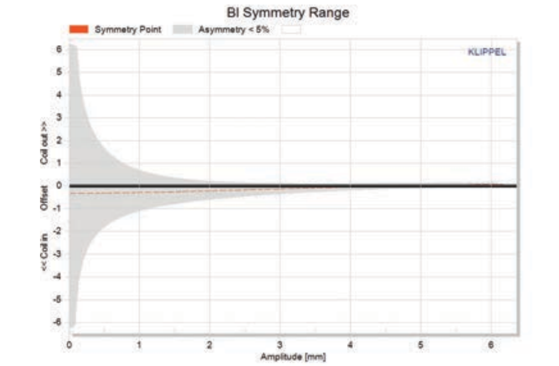


Figure 14: Klippel analyzer Bl symmetry range curve for the Tang Band W3-2052S

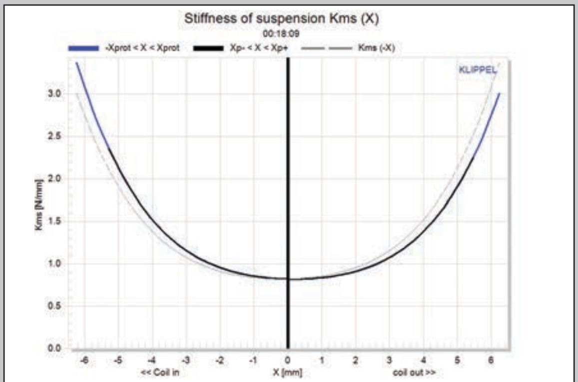


Figure 15: Klippel analyzer mechanical stiffness of suspension K_{MS} (X) curve for the Tang Band W3-2052S

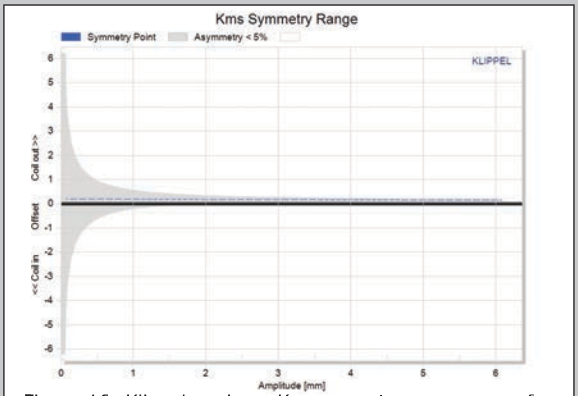


Figure 16: Klippel analyzer K_{MS} symmetry range curve for the Tang Band W3-2052S

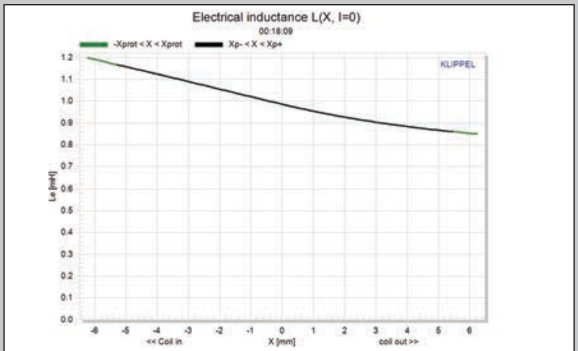


Figure 17: Klippel analyzer L(X) curve for the Tang Band W3-2052S

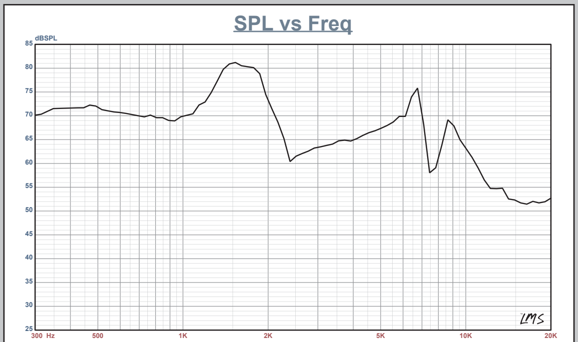


Figure 18: Tang Band W3-2052S on-axis frequency response

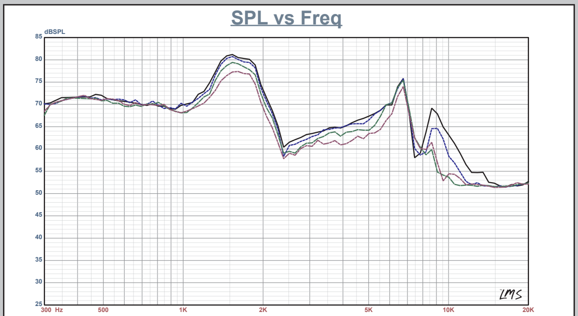


Figure 19: Tang Band W3-2052S on- and off-axis frequency response (black solid = 0°, blue dot = 15°, green dash = 30°, and purple dash dot = 45°)

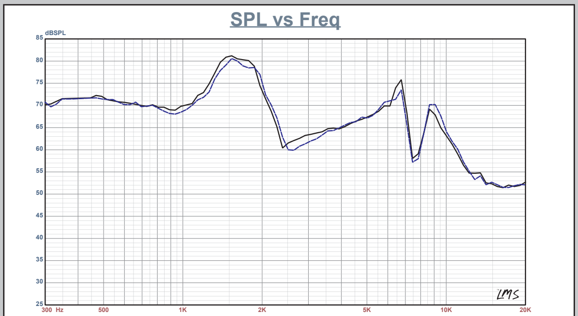


Figure 20: Tang Band W3-2052S woofer two-sample SPL comparison

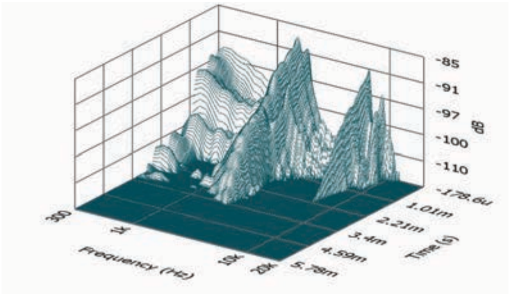


Figure 21: Tang Band W3-2052S woofer SoundCheck CSD waterfall plot

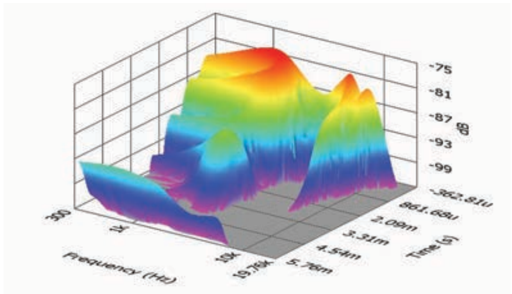


Figure 22: Tang Band W3-2052S Wigner-Ville plot

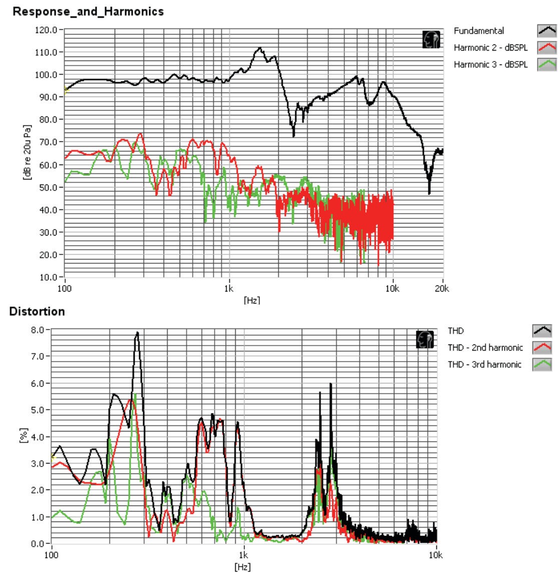


Figure 23: Tang Band W3-2052S SoundCheck distortion plots

the Klippel analyzer using the subwoofer criteria for Bl was XBl at 70% (Bl dropping to 70% of its maximum value) equal to 4.6 mm for the prescribed 20% distortion level. For the compliance, crossover at 50% C_{MS} minimum was 4.2 mm (0.8 mm less than the driver's physical X_{MAX}). This means that for the W3-2052S, the compliance is the more limiting factor for getting to the 20% distortion level.

Figure 17 shows the W3-2052S's inductance curve Le(X). Motor inductance will typically increase in the rear direction from the zero rest position and decrease in the forward direction as the voice coil moves out of the gap and has less pole coverage, which is what we see here. However, the inductive change is a minimal 0.15 mH from the rest position to X_{MAX} in either direction.

After the Klippel analysis was finished, I mounted the driver in an enclosure with a 5″ × 12″ baffle area and filled it with foam-damping material. Next, I used the LMS gated sine wave technique to measure the W3-2052S's SPL on- and off-axis. **Figure 18** shows the on-axis response measured 300 Hz to 20 kHz at 2.83 V/1 m. Even though the response is pretty ragged, you should still be able to cross this driver up to 800 Hz, if required. **Figure 19** shows the on- and off-axis to 45° and confirms this. Finally, **Figure 20** shows the two-sample SPL comparison revealing a close match in the relevant operating range.

I used the Listen SoundCheck analyzer to perform time-delay and distortion analysis. I normally dispense with time-delay frequency analysis for subwoofers as the data is not really significant below 100 Hz. However since the W3-2052S could be crossed higher than that, I will include those measurements. With the subwoofer still mounted in a foam damped enclosure with a 8″ × 12″ baffle, I proceeded to make an impulse measurement with SoundCheck. I imported the result into Listen's SoundMap software, which was windowed to remove the room reflections. **Figure 21** shows the CSD waterfall plot. **Figure 22** shows the Wigner-Ville plot.

For the distortion measurements, I set the voltage level with the driver mounted in free air and rigidly attached to a fixture. I used pink noise to increase the voltage until it produced a 1-m SPL of 94 dB (14.4 V), which is my SPL standard for home audio drivers. I made the distortion measurement with the microphone placed near-field (10 cm) with the woofer mounted in the enclosure.

Figure 23 shows the distortion plot. The top graph shows the standard fundamental SPL curve with the second- and third-harmonic curves. The bottom graph shows the second- and third-harmonic curves plus the THD curve with an appropriate X-axis scale.

Overall, the W3-2052S is a uniquely conceived dual-surround and dual-diaphragm driver and a well-performing mini subwoofer. For more information, visit www.tb-speakers.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:

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(503-557-0427)
vdconsult@comcast.net