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VOICE COIL
THE PERIODICAL FOR THE LOUDSPEAKER INDUSTRY

The 5F/8422T01

As you may know, 2″ diameter full-range drivers are currently one of the most used transducers in consumer electronics. They are finding broad use in soundbars, pedestal soundbars (i.e., soundbars that contain down-firing subwoofers that double as a TV stand), docking stations (these are starting to disappear in favor of Bluetooth connectivity), and desktop speakers (e.g., Sonos, Jambox, Dr. Dre, Samsung, Bose, and other products). However, Scan-Speak set out to make the best 2″ full range on the market, and I think it did well with the new 5F/8422T01.

The Scan-Speak 5F/8422T01 is a 2″ diameter full-range driver built on a proprietary injection-molded polymer frame that is fully vented below the spider mounting shelf for enhanced cooling. The cone assembly consists of a one-piece cone/dustcap suspended with a foam surround and a black cloth flat spider (damper). For a 2″ driver, the 5F/8422T01 has a rather large 26-mm diameter voice coil wound with round copper wire on a titanium former, terminated to opposite mounted solderable terminals. Driving the cone assembly is a neodymium motor with a neodymium ring magnet rather than a slug and a polished milled return cup. A large 15-mm diameter pole vent provides additional cooling. In the 5F/8422T01 literature, Scan-Speak notes that the frame is made in Denmark and all its soft parts are European.

To begin testing, I used the LinearX LMS analyzer and VIBox to create voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 0.3, 1, 3, and 6 V. I discarded the 6-V curves as too nonlinear for LEAP 5 to get a good curve fit. As is Test Bench's protocol, I no longer use a single added mass

Photo 3: Scan-Speak's 5F/8422T01 is a 2″ diameter full-range driver.

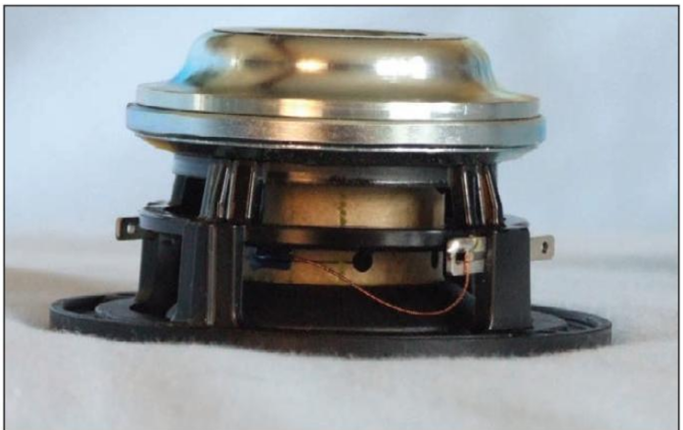

Photo 4: A neodymium motor with a neodymium ring magnet and a polished milled return cup drives the 5F/8422T01's cone assembly.

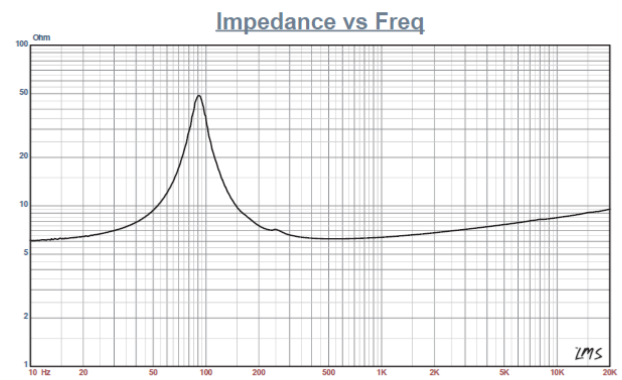

Figure 18: Scan-Speak 5F/8422T01 woofer 1-V free-air impedance plot

	TSL Model		LTD Model		Factory
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	94.7 Hz	91 Hz	89.4 Hz	86.7 Hz	93 Hz
R_{EVC}	5.6	5.64	5.6	5.64	6
Sd	0.0016	0.0016	0.0016	0.0016	0.00152
Q_{MS}	5.52	5.46	5.99	4.87	5.17
Q_{ES}	0.69	0.71	1	0.96	0.69
Q_{TS}	0.61	0.63	0.86	0.8	0.61
V_{AS}	0.55 ltr	0.59 ltr	0.62 ltr	0.65 ltr	0.5 ltr
SPL 2.83 V	80.1 dB	79.7 dB	78.3 dB	78.3 dB	80 dB
X_{MAX}	2 mm	2 mm	2 mm	2 mm	2 mm

Table 2: Comparison data for the Scan-Speak 5F/8422T01

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measurement. Instead I use actual measured mass, and the manufacturer's measured Mmd data. Next, I post-processed the six 550-point stepped sine wave sweeps for each of the 5F/8422T01 samples and divided the voltage curves by the current curves (admittance) to produce the impedance curves, which were phase generated by the LMS calculation method. I imported them along with the accompanying voltage curves to the LEAP 5 Enclosure Shop software.

Since most T-S data provided by OEM manufacturers is produced using either a standard method or the LEAP 4 TSL model, I additionally created a LEAP 4 TSL model using the 1-V free-air curves. I selected the complete data set, the multiple voltage impedance curves for the LTD model, and the 1-V impedance curve for the TSL model in LEAP 5's transducer derivation menu to create the parameters

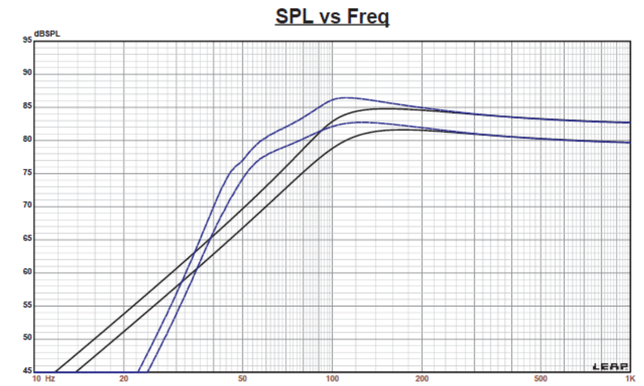

Figure 19: Scan-Speak 5F/8422T01 computer box simulations (black solid = sealed at 2.83 V; blue dash = vented at 2.83 V; black solid = sealed at 4.2 V; blue dash = vented at 4.2 V)

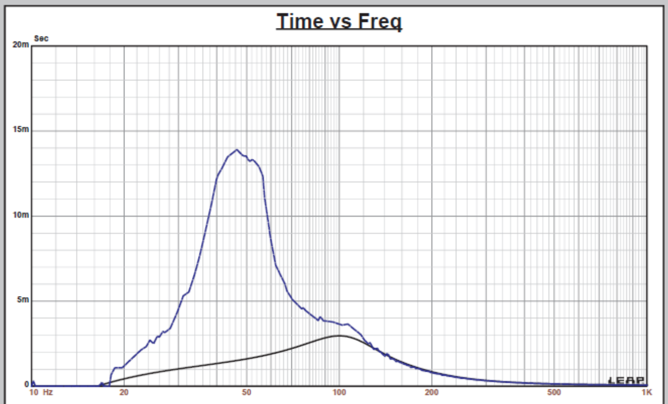

Figure 20: Group delay curves for the 2.83-V curves in Figure 19

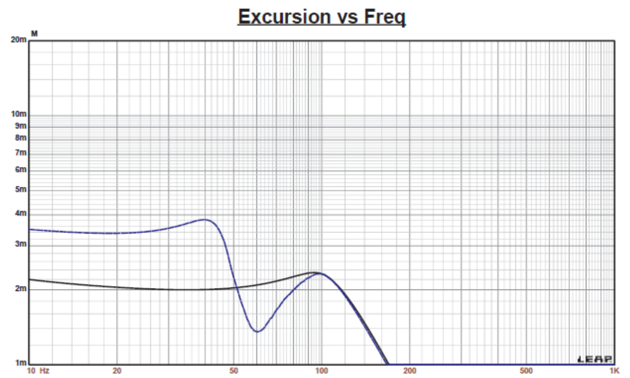

Figure 21: Cone excursion curves for the 4.2-V curves in Figure 19

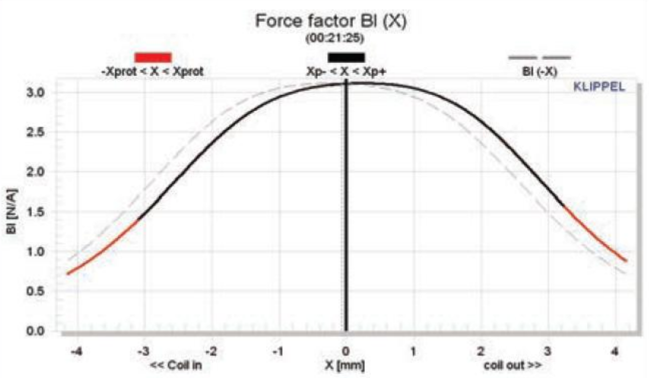

Figure 22: Klippel Analyzer Bl (X) curve for the Scan-Speak 5F/8422T01

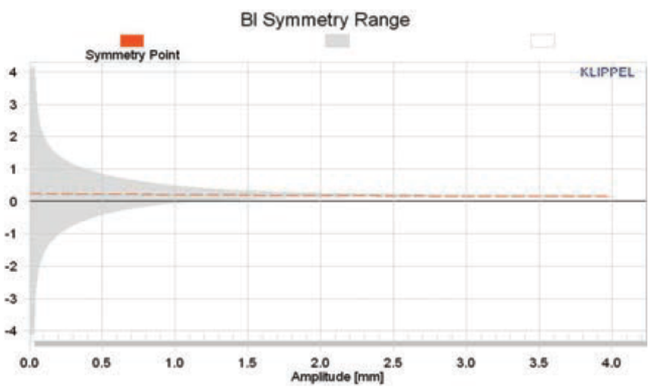

Figure 23: Klippel Analyzer Bl symmetry range curve for the Scan-Speak 5F/8422T01

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for the computer box simulations. **Figure 18** shows the 1-V free-air impedance curve. **Table 2** compares the LEAP 5 LTD, the TSL data, and the factory parameters for the 5F/8422T01 samples.

The 5F/8422T01's LEAP TSL parameter calculation results were similar to the factory data, while the Q_{TS} for the LTD multivoltage parameters exhibited a somewhat higher number. However, I followed my usual protocol and used the LEAP LTD parameters to set up computer enclosure simulations for Sample 1. I programmed two computer enclosure simulations into LEAP—a 60-in³ sealed-box alignment (with 50% damping material in the box) and a 112-in³ Chebychev/Butterworth-type vented alignment tuned to 55 Hz (with 15% damping material in the box).

Figure 19 shows the 5F/8422T01's results in the two box simulations at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to 2.3 mm (X_{MAX} + 15%). This produced a F3 frequency of 93 Hz with a box/driver Q_{TC} of 0.87 for the 60-in³ sealed enclosure and −3 dB = 74 Hz for the 112-in³ vented simulation. Increasing the voltage input to the simulations until the maximum linear cone excursion was reached resulted in 85 dB at 4.2 V for the sealed enclosure simulation and 86.5 dB with the same 4.2-V input level for the vented enclosure. **Figure 20** and **Figure 21** show the 2.83-V group delay curves and the 4.2-V excursion curves, respectively.

Turnmire performed the 5F/8422T01's Klippel analysis, which produced the Bl(X), K_{MS}(X), and Bl and K_{MS} symmetry range plots shown in **Figures 22–25**. **Figure 22** shows the

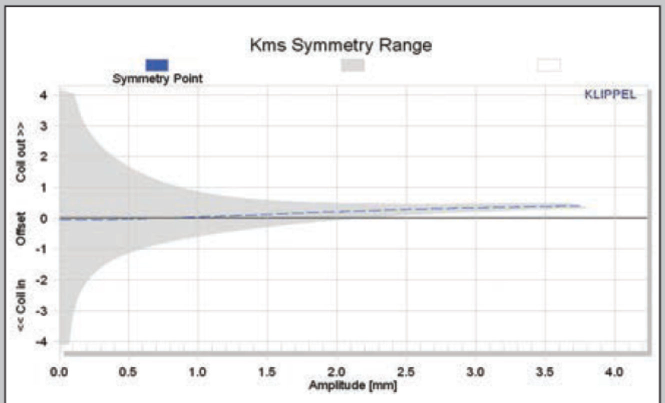

Figure 25: Klippel analyzer K_{MS} symmetry range curve for the Scan-Speak 5F/8422T01

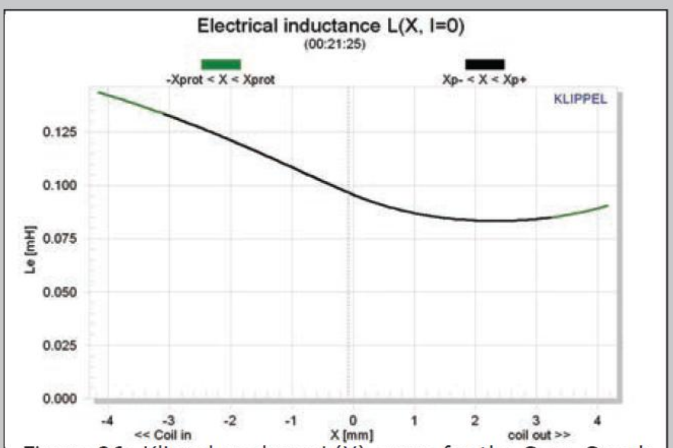

Figure 26: Klippel analyzer L(X) curve for the Scan-Speak 5F/8422T01

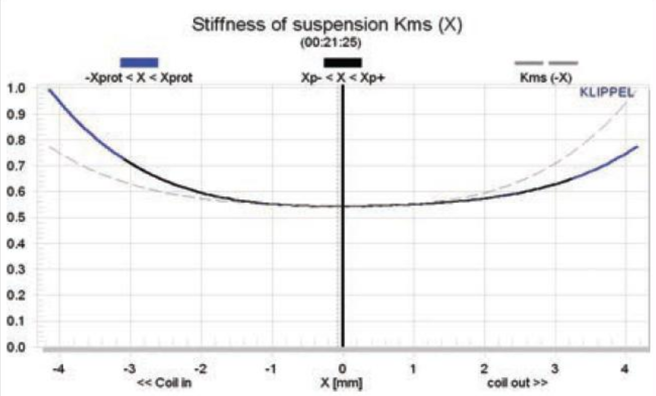

Figure 24: Klippel analyzer mechanical stiffness of suspension K_{MS} (X) curve for the Scan-Speak 5F/8422T01

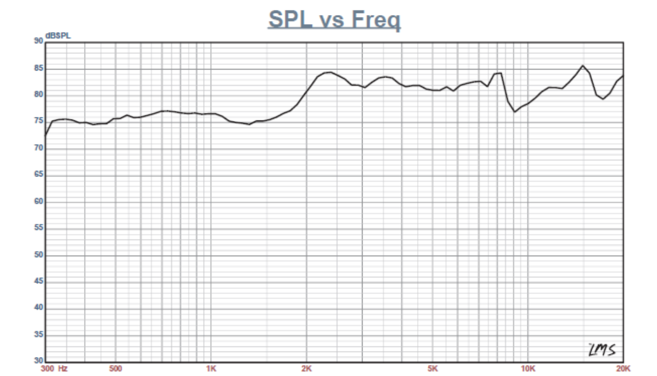

Figure 27: Scan-Speak 5F/8422T01 on-axis frequency response

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5F/8422T01's Bl(X) curve is relatively broad and symmetrical, especially for a short X_{MAX} 2″ diameter driver. **Figure 23** shows a minor 0.25-mm coil-out (forward) offset at the rest position that decreases to 0.19 mm at the driver's physical 2-mm X_{MAX}, which probably is within this product's assembly tolerance.

Figure 24 and **Figure 25** show the K_{MS}(X) and K_{MS} Symmetry Range curves for the Scan-Speak full-range driver. The K_{MS}(X) curve is fairly symmetrical, and also has a very minor forward (coil-out) offset of less than 0.05 mm at the rest position, increasing to likewise not significant 0.22 mm at the physical X_{MAX} position. I used the Klippel analyzer to calculate the 5F/8822T01's displacement limiting numbers, which were XBl at 82% (Bl is 1.8 mm) and the crossover at 75% C_{MS} minimum was 3.2 mm. The numbers indicated that Bl is the 5F/8822T01's most limiting factor for a 10% prescribed distortion level.

Figure 26 shows the 5F/8822T01's inductance curve 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 5F/8822T01's inductance variation is only 0.04 mH from the in and out X_{MAX} positions, which is very good.

Next I mounted the 5F/8822T01 in an enclosure with a 4″ × 9″ baffle filled with damping material (foam). I set the Linear LMS analyzer 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 27** shows the 5F/8822T01's on-axis response, which indicates

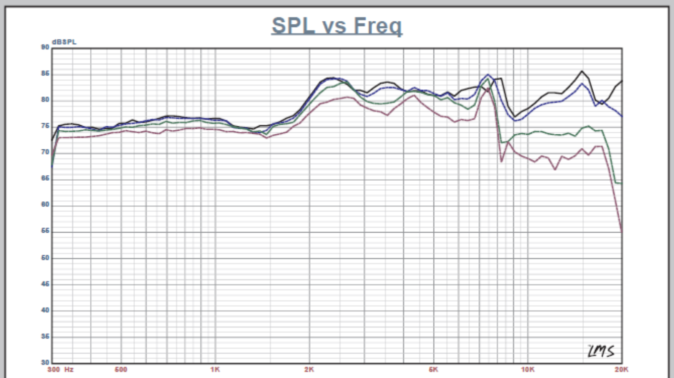

Figure 28: Scan-Speak 5F/8422T01 on- and off-axis frequency response (black solid =0°, blue dot = 15°, green dash = 30°, purple dash dot = 45°)

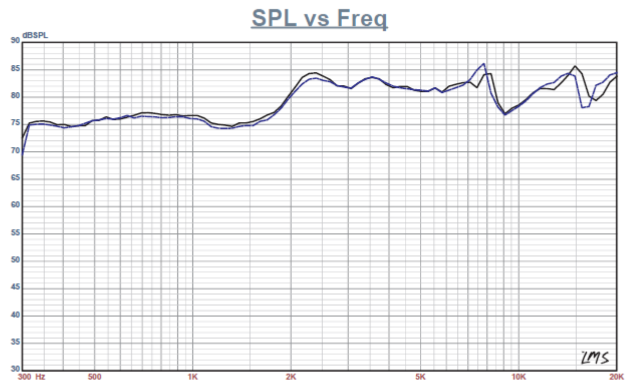

Figure 29: Scan-Speak 5F/8422T01 woofer two-sample SPL comparison

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a smoothly rising response to about 1.5 kHz, increasing to roughly 7 dB out to 10 kHz.

One mistake designers make is not equalizing the upper rise. If you do not, it makes the speaker sound thin and lack bottom end. The trade-off is that the device's apparent loudness decreases. Some of these small two-driver Bluetooth devices have closely mounted woofers with no possibility of any stereo phantom center. One solution is to drive them in parallel as a mono source. This increases the product efficiency by 3 dB.

Figure 28 shows the on- and off-axis frequency response at 0°, 15°, 30°, and 45°. The roll-off at 30° off-axis is almost as good as a 1" dome, so I would expect this driver's full-range fidelity to be quite good. **Figure 29** shows the 5F/8822T01's two-sample SPL comparison with a close match to within less than 1 dB throughout the operating range.

I used the Listen SoundCheck AmpConnect analyzer with the 0.25" SCM microphone and the power supply to measure distortion and generate time-frequency plots. For the distortion measurement, I rigidly mounted the 5F/8822T01 in free-air and used a noise stimulus to set the SPL to 94 dB at 1 m (7.2 V). Next, I measured the distortion with the microphone placed 10 cm from the dust cap. This produced the distortion curves shown in **Figure 30**. 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 31** shows the CSD waterfall plot. **Figure 32** shows the Wigner-Ville plot. While this Scan-Speak 2" full-range driver's intended applications are TV, multimedia, and lifestyle speakers, I think the 5F/8822T01 would make a great driver for line-source applications. For more information on this well-crafted driver, visit www.scan-speak.dk. ***VC***

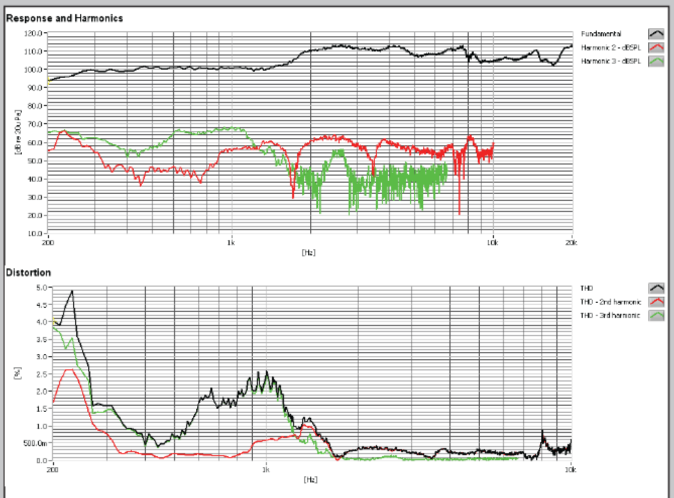

Figure 30: Scan-Speak 5F/8422T01 SoundCheck distortion plot

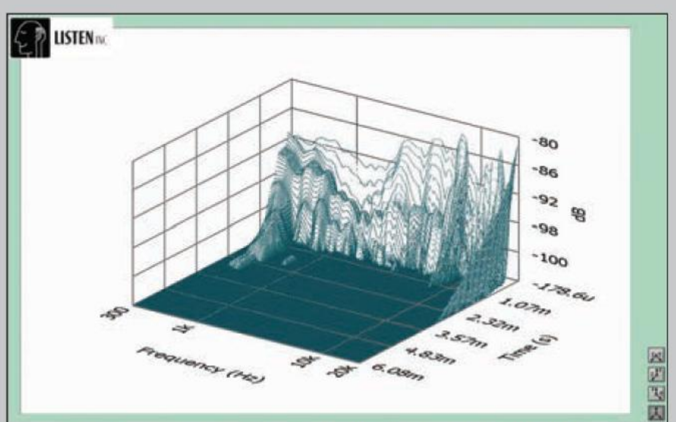

Figure 31: Scan-Speak 5F/8422T01 SoundCheck CSD waterfall plot

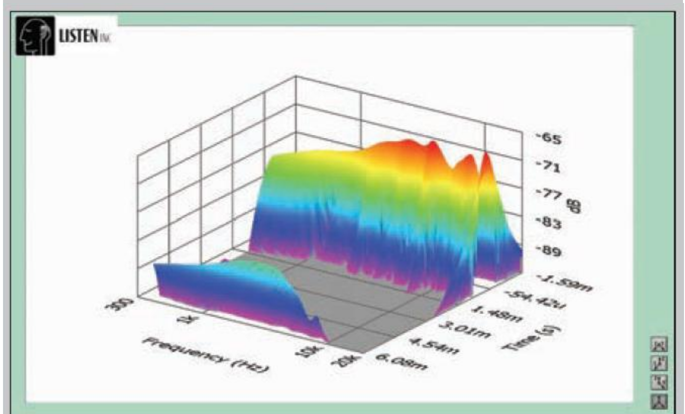

Figure 32: Scan-Speak 5F/8422T01 SoundCheck Wigner-Ville plot