By Vance Dickason (United States)

A New Tweeter and a New Woofer

Testing two high-end home audio drivers

Both of the drivers submitted to test bench are for home audio applications, and both are from SB Acoustics. SB submitted their SB26STAC-C000-4, a ferrite motor 1" soft-dome tweeter, plus a new high-end 6.5" midwoofer, the MW16R Satori.

I have covered a number of SB Acoustics tweeters including: the ferrite motor 29-mm ring dome SB29RDC-C000-4 (*Voice Coil* August 2009); it's neodymium 29-mm ring dome version, the SB29RDNC-C000-4, (*Voice Coil* August 2011); and the SB26STCN-C000-4, a 1" neo-motor tweeter (*Voice Coil* September 2011). This month's addition is the ferrite version of the SB26STCN, the 1" SB26STAC-C000-4 (see **Photo 1**). It bears repeating that SB is the initials for Sinar Baja, which is a large OEM driver manufacturer located in Indonesia. However, the driver line is the brainchild of David Stephens, former U.S. representative of DST. Keeping with his Danish driver heritage, David is closely associated with former Vifa/Scan-Speak engineers Ulrik Schmidt and Frank Nielsen, now co-owners of Danesian Audio. Danesian Audio does all the transducer engineering for SB Acoustics.

In terms of features, the SB26STAC employs a 1" (26-mm) diameter, treated cloth-dome diaphragm, a 1" underhung voice coil with 0.6 mm Xmax and wound with CCAW wire, damped vented pole, exhausting into a damped rear chamber, a copper cap (shorting ring) on the vented pole, silver alloy lead wires terminating to gold terminals, and a cast aluminum faceplate. SB also offers a slightly lower cost version with an injection-molded plastic faceplate, the SB26STC.

Testing commenced using the LinearX LMS analyzer to produce the 300-point impedance sweep, illustrated in **Figure 1**. The magnetic fluid damped resonance occurs at a moderately low 731 Hz. With a 2.96-Ω DCR, the minimum impedance for this tweeter is 3.1 Ω at 2.1 kHz.

Following the impedance test, I recess mounted the SB tweeter in an enclosure that had a baffle area of 10" × 8" and measured the on- and off-axis frequency response with a 100-point gated sine wave sweep at 2.83 V/1 m. **Figure 2** shows the on-axis response to be a very flat ±2.05 dB from 1 kHz to 13 kHz, and from 1 kHz to 29 kHz, ±3.1 dB. **Figure 3** depicts the on- and off-axis response of SB26STAC, with the off-axis curves normalized to the on-axis response in **Figure 4**. The two-sample SPL comparison is illustrated in **Figure 5**, indicating the two samples were closely matched, with a small 1 dB variation between 4.5 kHz to 6 kHz.

The next test procedure was to fire up the Listen, Inc. SoundCheck analyzer along with the Listen, Inc.

Photo 1: The SB26STAC-C000-4, a 1" soft-dome tweeter

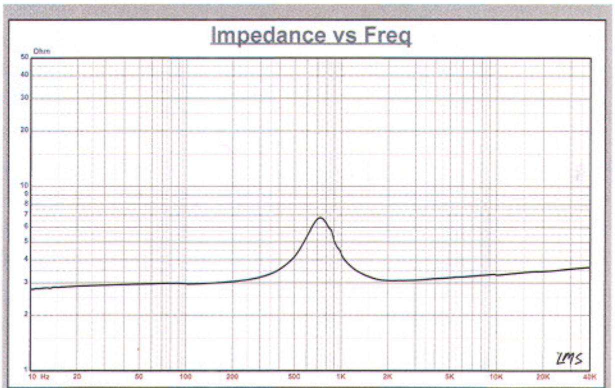

Figure 1: SB Acoustics SB26STAC-C000-4 free-air impedance plot

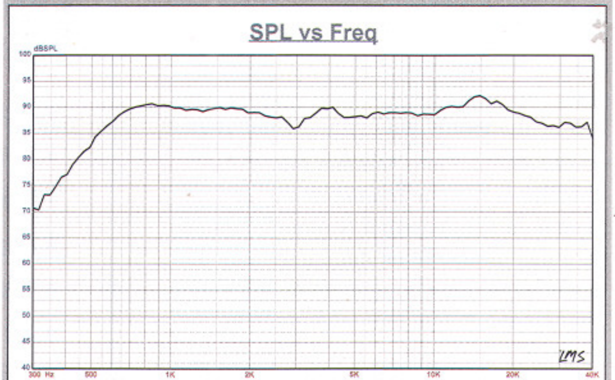

Figure 2: SB Acoustics SB26STAC-C000-4 on-axis response

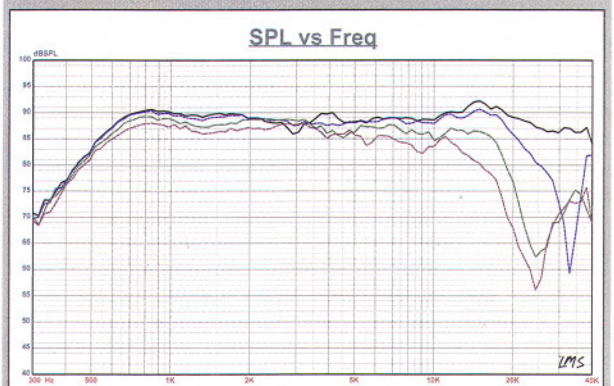

Figure 3: SB Acoustics SB26STAC-C000-4 horizontal on- and off-axis frequency (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot)

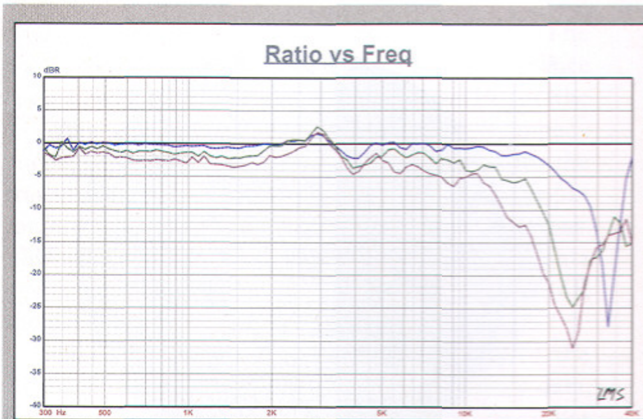

Figure 4: SB Acoustics SB26STAC-C000-4 normalized on- and off-axis frequency response (0° = solid; 15° = dot; 30° = dash; 45° = dash/dot)

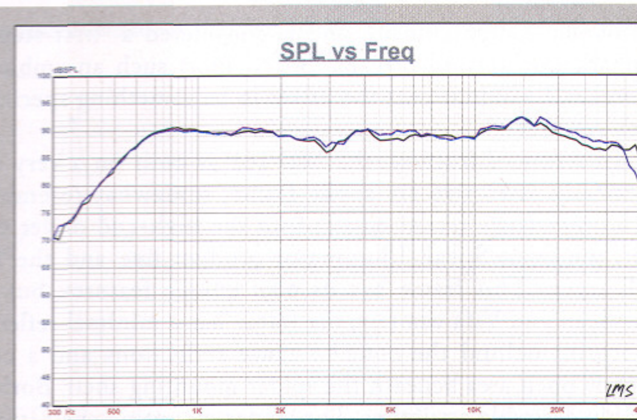

Figure 5: SB Acoustics SB26STAC-C000-4 two-sample SPL comparison

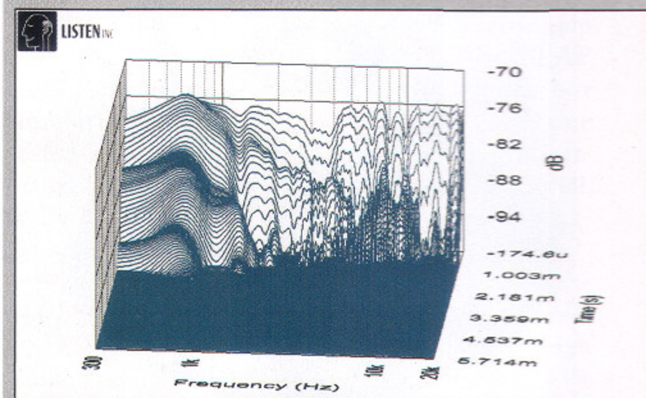

Figure 6: SB Acoustics SB26STAC-C000-4 Soundcheck CSD waterfall plot

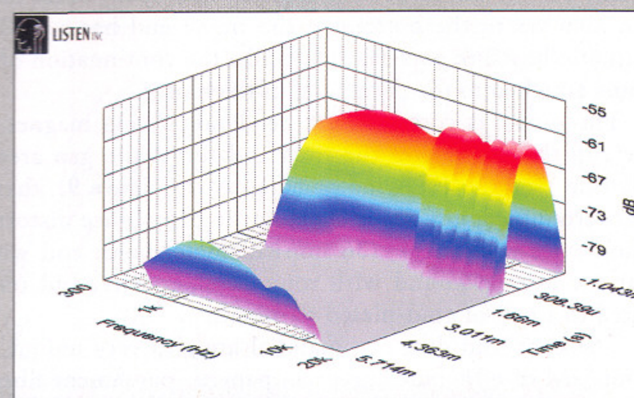

Figure 7: SB Acoustics SB26STAC-C000-4 Sound Check STFT surface intensity plot

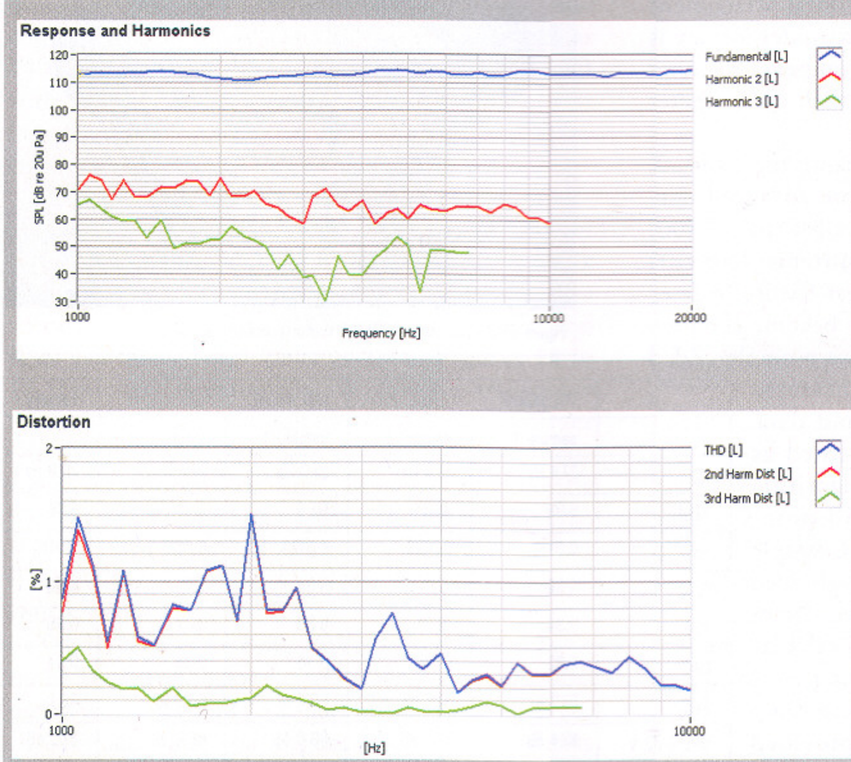

Figure 8: SB Acoustics SB26STAC-C000-4 SoundCheck distortion plots

SCM ¼" microphone (provided courtesy of Listen, Inc.) to measure the impulse response with the tweeter recess mounted on the test baffle. Importing this data into the Listen, Inc. SoundMap software produced the cumulative spectral decay plot (usually referred to as a "waterfall" plot) given in **Figure 6**. **Figure 7** is a Short Time Fourier Transform (STFT) displayed as a surface plot. For the final test procedure, I set the 1 m SPL to 94 dB (4.2 V) using a noise stimulus, and measured the 2nd and 3rd harmonic distortion at 10 cm, depicted in **Figure 8**.

The next SB Acoustics driver is part of what I assume will be a complete new series of ultra-high-end transducers for SB, the Satori line. So far, there are only two drivers in this line, the Satori TW29R (similar to the SB29RDC-C000-4 ring dome) and the subject of this report, the Satori MW16R (see **Photo 2a** and **2b**). In the Zen Buddhist tradition, satori refers to a flash of sudden awareness, or individual enlightenment, and is considered a "first step" or embarkation toward nirvana. So, to sport such an ambitious moniker, I would expect the driver to be something special, so let's get to it.

In terms of features, the MW16P is built on a very cosmetically attractive six-spoke frame, somewhat resembling two other fairly recent entries into the high-end driver market, the Scan-Speak Illuminator product line and the Vifa NE series. This frame has its own unique features, but like the Scan and Vifa woofers, the frame has a minimal reflective footprint behind the cone to cause reflections and a completely open area beneath the spider mounting shelf. Both are highly desirable attributes. The spider mounting shelf itself is pinned to the frame to limit vibration transfer from the frame to this part of the suspension system. The neodymium motor cup attaches to the bottom of the frame and has a separate cosmetic/heatsink part that looks like the continuation of the frame attached to the peripheral of the motor.

The motor is comprised of neodymium ring magnet and the cup that completes the field and forms the gap area. In addition (see the FEA motor cutaway in **Figure 9**), there is an overhung copper sleeve shorting ring to reduce distortion. The device uses a 1.4" (36 mm) diameter voice coil with a Kapton former wound with round copper wire, and terminated to a pair of gold-plated terminals.

The cone and dust cap material are also very unique and composed of 60% pure Egyptian papyrus parchment fibers, a very expensive, but light and stiff material. This incidentally is available in the black cone seen in the accompanying photo, as well as a natural off-white color if you are going for that Yamaha NS-10 look. Suspension is provided by a NBR surround that uses a special vertical and horizontal attachment process, along with a Dr. Kurt Muller Bimax spider. Bimax is purported to have less twisting tendencies compared to other cloth spider materials and is warm shaped with a durometer resin.

I commenced analysis of the MW16R using the LinearX LMS analyzer (soon to be replaced by a more advanced outboard chassis with USB interface analzyer called the LX500) and VIBox to create both voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 0.3 V, 1 V, 3 V, 6 V, and 10 V. As has become the protocol for Test Bench testing, I no longer use a single added mass measurement and instead used actual measured mass, but the manufacturer's measured Mmd data. At this point, the 10-V curves were discarded as being too nonlinear for the curve-fitting algorithm to resolve. Next, the remaining eight 550-point stepped sine wave sweeps for each MW16R sample were post-processed and the voltage curves divided by the current curves (admittance curves) to derive impedance curves, phase added by the LMS calculation method, and along with the accompanying voltage curves, imported to the LEAP 5 Enclosure Shop software. Since most Thiele-Small data provided by the majority of OEM manufacturers is generated using either the standard model or the LEAP 4 TSL model, I additionally created a LEAP 4 TSL

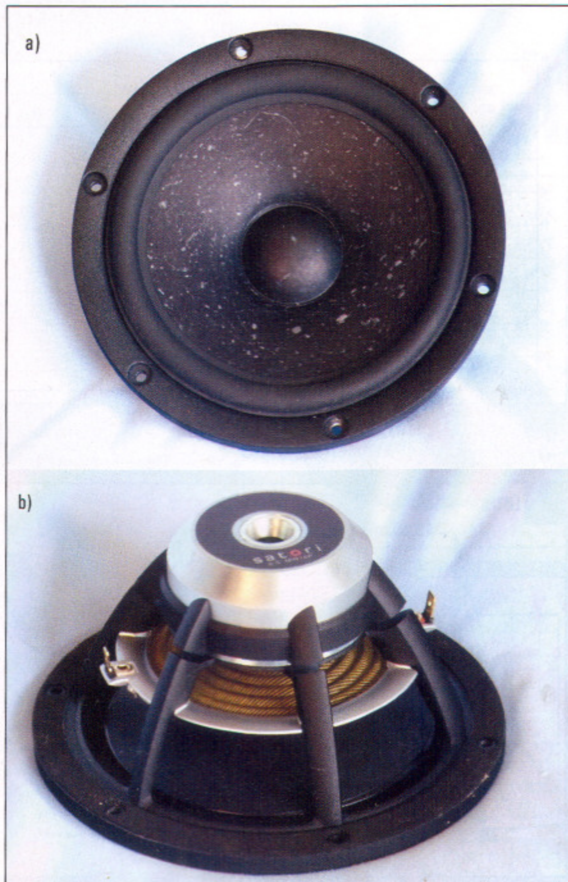

Photo 2: The top (a) and bottom (b) of the Satori MW16R

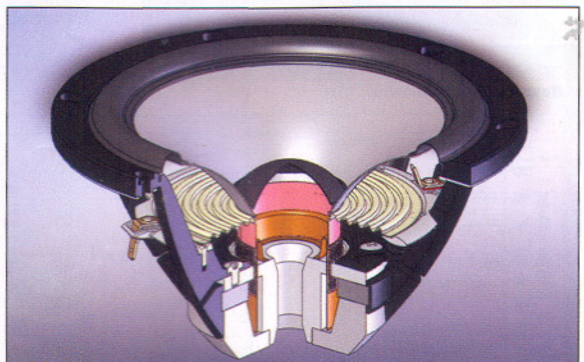

Figure 9: SB Acoustics MW16R motor cutaway drawing

	TSL model		LTD model		Factory
	sample 1	sample 2	sample 1	sample 2	
FS	27.6 Hz	27.6 Hz	27.0 Hz	27.0 Hz	29.0 Hz
REVC	5.99	6.01	5.99	6.01	6.20
Sd	0.0123	0.0123	0.0123	0.0123	0.0119
QMS	5.60	5.33	5.35	5.75	4.50
QES	0.34	0.37	0.38	0.42	0.35
QTS	0.32	0.35	0.35	0.39	0.34
VAS	57.2 ltr	57.1 ltr	60.2 ltr	60.0 ltr	48 ltr
SPL 2.83 V	87.4 dB	87.0 dB	86.8 dB	86.4 dB	87.5 dB
XMAX	6.0 mm	6.0 mm	6.0 mm	6.0 mm	6.0 mm

Table 1: SB Acoustics Satori MW16R midwoofer

parameter set using the 1-V free-air curves. The complete data set, the multiple voltage impedance curves for the LTD model (see **Figure 10** for the 1-V free-air impedance curve) and the 1-V impedance curve for the TSL model were selected in the transducer derivation menu in LEAP 5 and the parameters created for the computer box simulations. **Table 1** compares the LEAP 5 LTD and TSL data and factory parameters for both of Satori MW16R samples.

LEAP TS parameter calculation results for the MW16R were reasonably close to the factory data, however my data definitely showed a lower Vas compared to the factory data. Although the preliminary factory data showed some variation, I followed my usual protocol and proceeded setting up computer enclosure simulations using the LEAP LTD parameters for Sample 1. Two computer box simulations were programmed into LEAP, one sealed and one vented. This resulted in a 0.5 ft^3 sealed enclosure with 50% fiberglass fill material, and a 1.0 ft^3 QB^3 vented enclosure with 15% fiberglass fill material and tuned to 30 Hz.

Figure 11 displays the results for the SB Acoustics Satori woofer in the sealed and vented boxes at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to Xmax + 15% (6.9 mm for the MW16R). This produced a F^3 frequency of 58 Hz with a box/driver Qtc of 0.69 for the 0.5 ft^3 sealed enclosure and –3 dB = 40 Hz for the 1.0 ft^3 vented simulation. Increasing the voltage input to the simulations until the maximum linear cone excursion was reached resulted in 101.5 dB at 14 V for the sealed enclosure simulation and 103 dB with a 13.5-V input level for the larger vented box (see **Figure 12** and **13** for the 2.83-V group delay curves and the 14/13.5-V excursion curves).

Klippel analysis for the SB Acoustics 6.5" woofer (our analyzer is provided courtesy of Klippel GmbH), performed by Pat Turnmire, Red Rock Acoustics (author of the SpeaD and RevSpeaD software) produced the Bl(X), Kms(X), and Bl and Kms symmetry range plots given in **Figures 14** to **17.** This data is extremely valuable for transducer engineering, so if you don't own a Klippel analyzer and would like to have analysis done on a particular driver project, Red Rock Acoustics can provide Klippel analysis of almost any driver for a nominal fee of $100 per unit. (For contact information, visit the Red Rock Acoustics website at www.redrockacoustics.com.)

The Bl(X) curve for the MW16R (see **Figure 14**) is fairly broad, but obviously with a component of asymmetry, with a forward (coil-out) offset. Looking at the Bl Symmetry plot (see **Figure 15**), this curve shows a 3.4-mm coil forward offset at the rest position that decreases to 1 mm at the 7 mm, just beyond the physical Xmax for this driver. One of the things I

Figure 10: SB Acoustics MW16R woofer free-air impedance plot

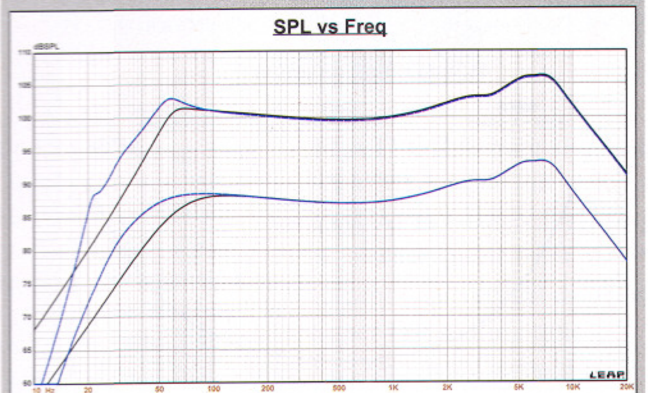

Figure 11: SB Acoustics MW16R computer box simulations (black solid = sealed @ 2.83 V; blue dash = vented @ 2.83 V; black solid = sealed @ 14 V; blue dash = vented @ 13.5 V)

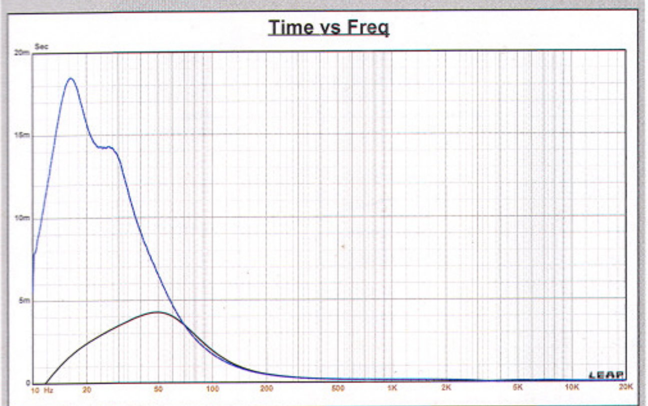

Figure 12: Group delay curves for the 2.83-V curves in Figure 11

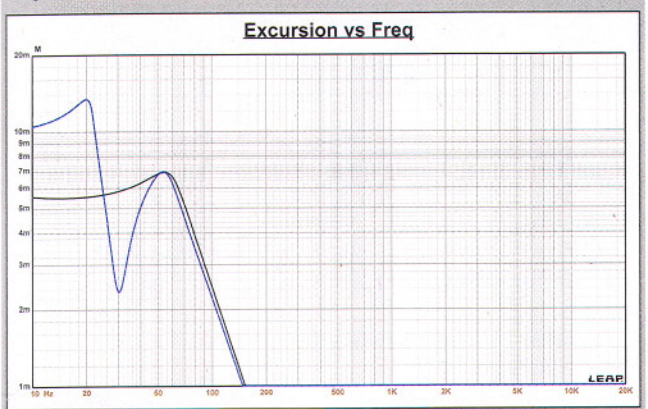

Figure 13: Cone excursion curves for the 14/13.5-V curves in Figure 11

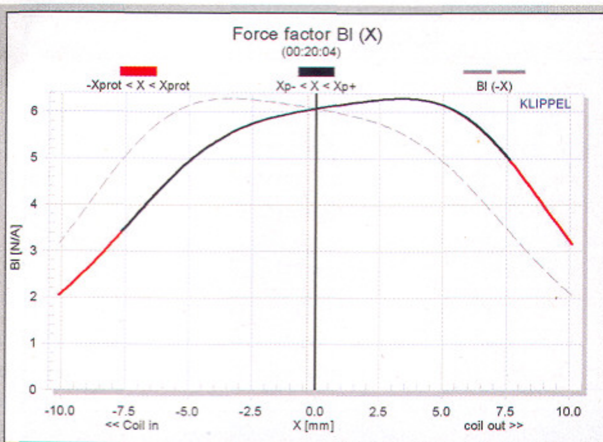

Figure 14: Klippel Analyzer Bl (X) curve for the SB Acoustics MW16R

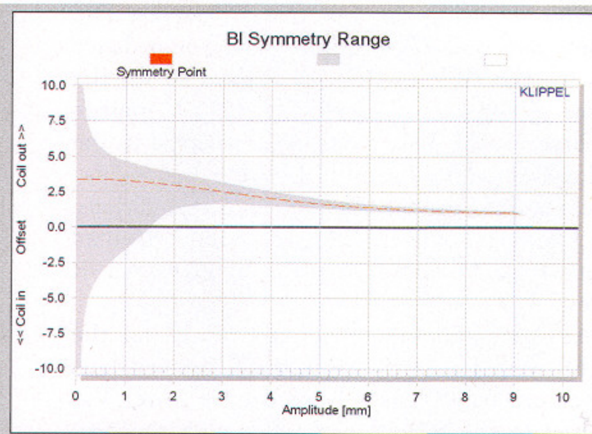

Figure 15: Klippel Analyzer Bl symmetry range curve for the SB Acoustics MW16R

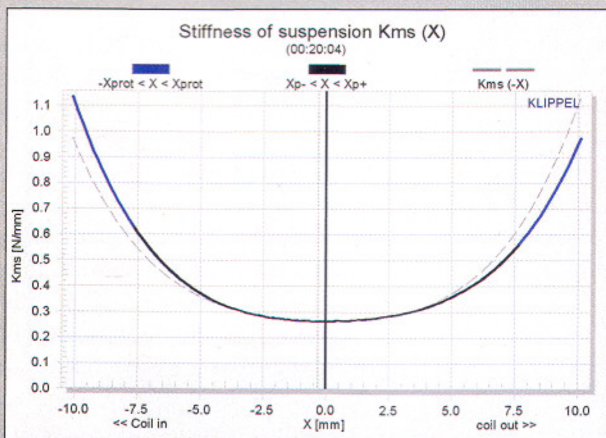

Figure 16: Klippel Analyzer mechanical stiffness of suspension Kms (X) curve for the SB Acoustics MW16R

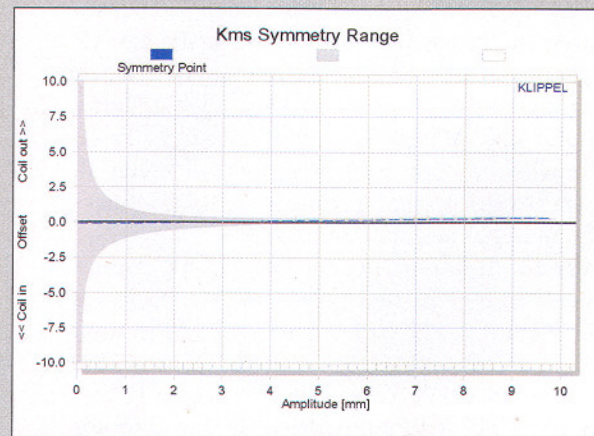

Figure 17: Klippel Analyzer Kms symmetry range curve for the SB Acoustics MW16R

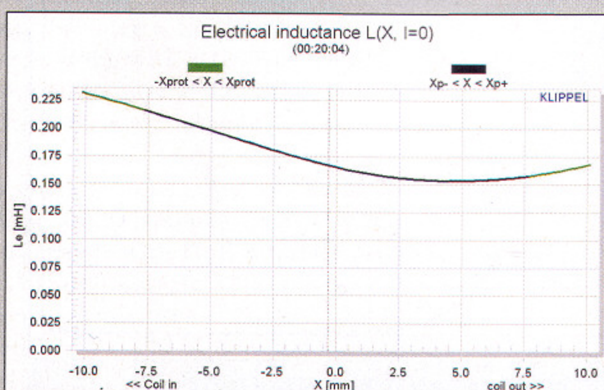

Figure 18: Klippel Analyzer Le(X) curve for the SB Acoustics MW16R

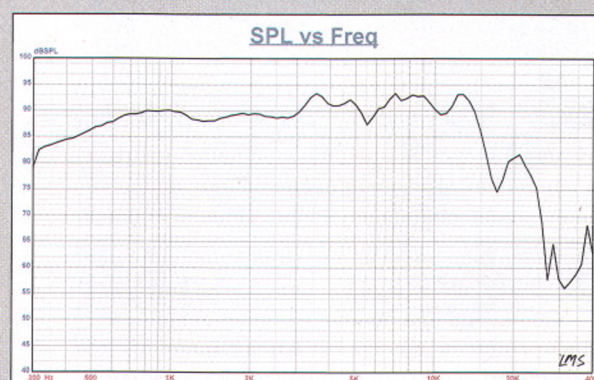

Figure 19: SB Acoustics MW16R on-axis frequency response

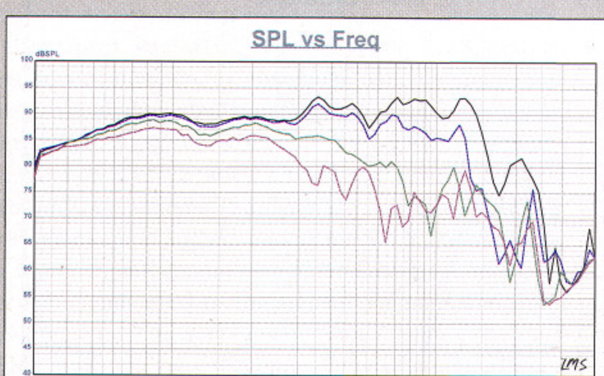

Figure 20: SB Acoustics MW16R on- and off-axis frequency response

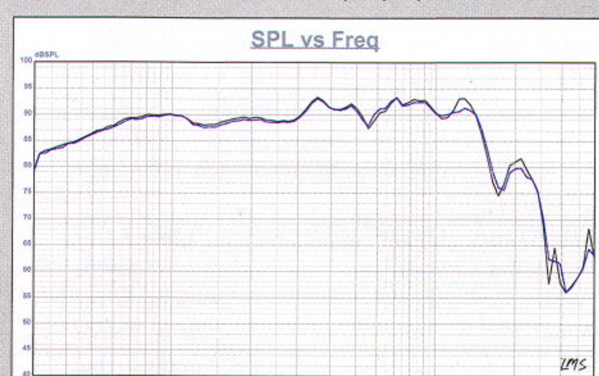

Figure 21: SB Acoustics MW16R two-sample SPL comparison

have not talked about very often is the grey area on the graph. This represents the area of uncertainty for the analyzer. Since Bl curves are typically flat until you reach the knee where Bl begins to decrease, it is difficult to resolve exactly what is happening to the motor system. **Figure 16** and **17** show the Kms(X) and Kms Symmetry Range curves for the SB Acoustics MW16R. The Kms(X) curve is very symmetrical in both directions, but also with a small rearward (coil-in) offset of about 0.1 mm at the rest position and transitioning to 0.1 mm-coil-out offset at the physical Xmax position. Looking at both sets of data, Bl and compliance, the conclusion is likely that the coil is about 1 mm offset from magnetic center. I say this because that is the offset at a place of strong certainty in the measurement at 7 mm.

Displacement limiting numbers calculated by the Klippel analyzer for the MW16R were XBl @ 82% Bl = 4.9 mm and for XC @ 75% Cms minimum was 4.6 mm, which means that for this Vifa woofer, the compliance is the most limiting factor for prescribed distortion level of 10%.

Figure 18 gives the inductance curves Le(X) for the Satori 6.5". Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area, which is what you see in the MW16R Le(X) curve, however, the variation is only 0.20 mH to 0.15 mH from the in and out Xmax positions, which is very good.

Next, I mounted the MW16R woofer in an enclosure which had a 13" × 6" baffle and was filled with damping material (foam) and then measured the DUT on- and off-axis from 300-Hz to 20-kHz frequency response at 2.83 V/1 m using the LinearX LMS analyzer set to a 100-point gated sine wave sweep. **Figure 19** gives the Satori woofer's on-axis response indicating a smoothly rising response to about 1 kHz then flattening out up to 3 kHz with a small amount of anomalous behavior up to the low-pass roll-off beginning at 16 kHz. **Figure 20** displays the on- and off-axis frequency response at 0°, 15°, 30°, and 45°. At 30°, –3 dB

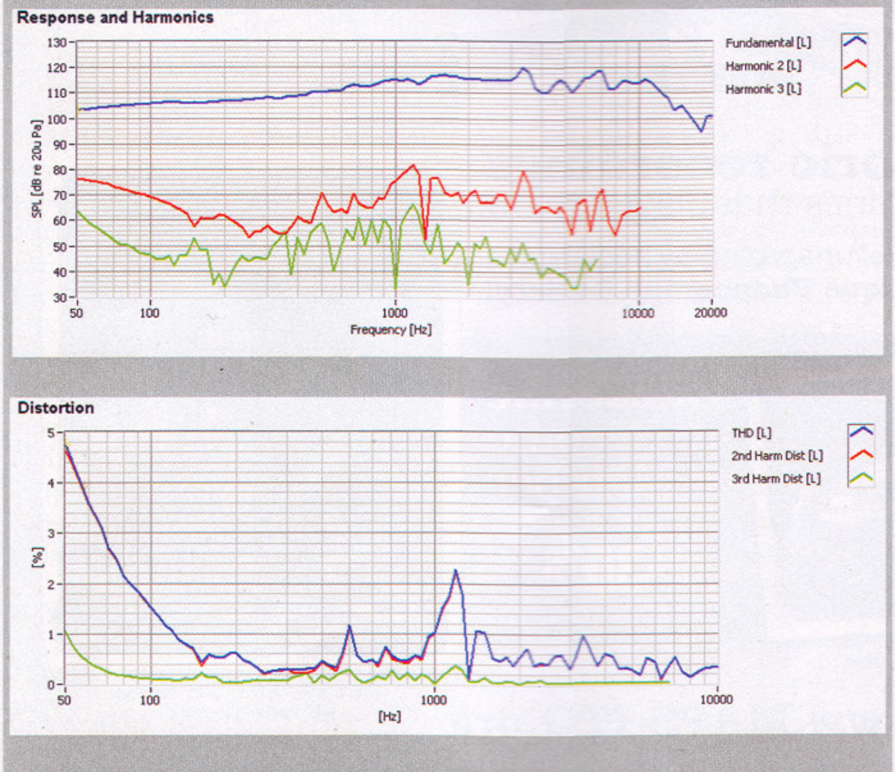

Figure 22: SB Acoustics MW16R SoundCheck distortion plots

with respect to the on-axis curve occurs at 2.8 kHz, so a cross point at 3 kHz or lower would be appropriate. And finally, **Figure 21** gives the two-sample SPL comparisons for the 6.5" SB driver, showing a close match to within 0.5 dB throughout the operating range.

For the remaining group of tests, I employed the Listen, Inc. SoundCheck analyzer and SCM ¼" microphone (courtesy of Listen, Inc.) to measure distortion and generate time frequency plots. For the distortion measurement, the Satori woofer was mounted rigidly in free-air, and the SPL set to 94 dB at 1 m (5.6 V) using a noise stimulus, and then the distortion measured at with the Listen, Inc. microphone placed 10 cm from the dust cap. This produced the distortion curves shown in **Figure 22**. I then used SoundCheck to get a 2.83 V/1 m impulse response for this driver and imported the data into Listen Inc.'s SoundMap Time/Frequency software. The resulting CSD waterfall plot is given in **Figure 23** and the Wigner-Ville (for its better low-frequency performance) plot in **Figure 24**.

All things taken together, and since I know that Frank and Ulrik (Danesian Audio) spend a lot of time listening to various iterations of a driver as they go through the development process, I'm guessing that this is a very fine sounding product. For more information on the SB-26STAC and MW16R Satori woofer and other SB Acoustics drivers, visit the SB Acoustics website at www.sbacoustics.com. *aX*

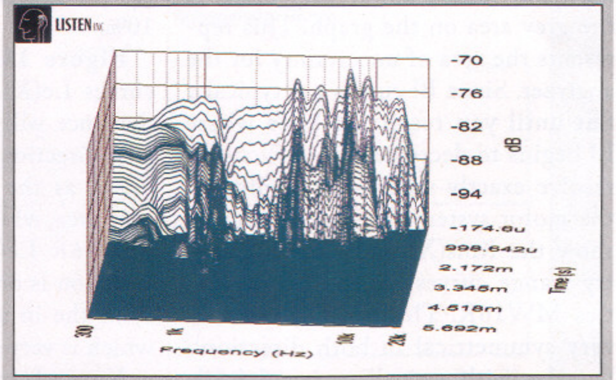

Figure 23: SB Acoustics MW16R SoundCheck CSD waterfall plot

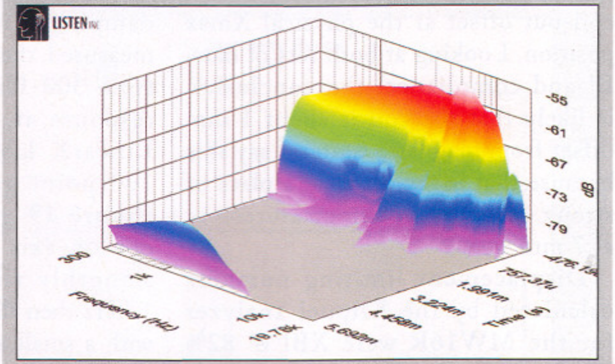

Figure 24: SB Acoustics MW16R SoundCheck Wigner-Ville plot