# Test Bench

## Wavecor Full-Range Driver and Eminence Guitar Speaker

By Vance Dickason

This month's driver submissions are both unique, but from nearly opposite ends of the transducer spectrum. From Wavecor, a 2.75" diameter full-range driver intended for high-quality multimedia and lifestyle (iPod docking stations) products—the FR070WA01; and, from Eminence, a new and extremely clever variable Bl 12" diameter guitar speaker—the Maverick.

### FR070WA01

The Wavecor FR070WA01 (Photos 1 and 2) is a 2.75" diameter full-range driver built on an injection-molded polymer frame that is fully vented below the spider mounting shelf for enhanced cooling. The cone assembly consists of a black anodized aluminum cone with a 1" diameter anodized aluminum dust cap. Suspending the cone and dust cap are a low loss NBR surround and a Conex spider. The FR070 has a 22mm diameter voice coil wound on a vented black glass fiber non-conducting former and terminated to a pair of gold-plated terminals. Powering this structure is a dual neodymium motor that includes a copper cap on the center pole and black colored motor parts (return cup) for better heat transfer to the surrounding air. I should also note that Wavecor makes a companion 2.75" subwoofer for this driver, the SW070WA.

PHOTO 1: Wavecor's FR070WA01.


PHOTO 2: FR07 top.

I commenced testing the FR070WA01 using the LinearX LMS analyzer and VIBox to produce both voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 0.3V, 1V, 3V, and 6V. 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 manufacturers' measured Mmd data. Next, I post-processed the eight 550-point stepped sine wave sweeps for each sample and divided the voltage curves by the current curves (admittance) to produce the impedance curves, phase generated by the LMS calculation method, and, along with the accompanying voltage curves, imported to the LEAP 5 Enclosure Shop software. Because most Thiele/Small data provided by OEM manufacturers is being produced using either a standard method or the LEAP 4 TSL model, I additionally produced a LEAP 4 TSL model using the 1V free-air curves. I selected the complete data set, the multiple voltage impedance curves for the LTD model (see Fig. 1 for the 1V free-air impedance curve) and the 1V impedance curve for the TSL model in the transducer derivation menu in LEAP 5, and produced the parameters for the computer box simulations. Table 1 compares the LEAP 5 LTD and TSL data and factory parameters for both FR070WA01 samples.

LEAP parameter calculation results for the FR070WA01 were close to the factory data, except for the sensitivity. However, mine is a calculated midband sensitivity that is part of the T/S calculation routine and Wavecor uses average SPL in the 400Hz-1kHz range. However, I followed my usual protocol and proceeded to set up computer enclosure simulations using the LEAP LTD parameters for Sample 1. I programmed two computer sealed box simulations

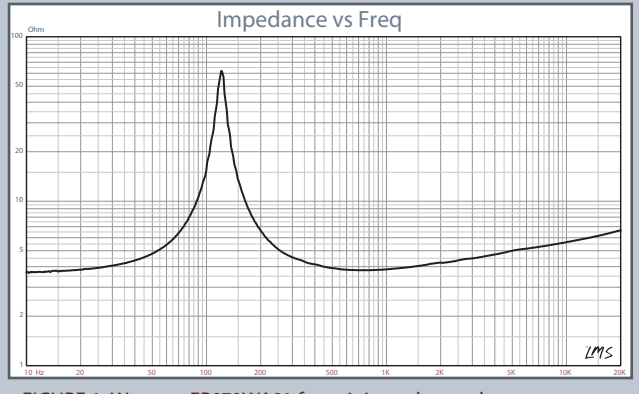

FIGURE 1: Wavecor FR070WA01 free-air impedance plot.

TABLE 1: Wavecor FR070WA01 Full-range

| | TSL model sample 1 | TSL model sample 2 | LTD model sample 1 | LTD model sample 2 | Factory |
|---|---|---|---|---|---|
| $F_S$ | 121Hz | 117Hz | 122Hz | 121Hz | 120Hz |
| $R_{EVC}$ | 3.52 | 3.50 | 3.52 | 3.50 | 3.45 |
| Sd | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 |
| $Q_{MS}$ | 11.7 | 11.0 | 8.21 | 9.03 | 12.8 |
| $Q_{ES}$ | 0.64 | 0.62 | 0.73 | 0.77 | 0.58 |
| $Q_{TS}$ | 0.61 | 0.59 | 0.67 | 0.71 | 0.55 |
| $V_{AS}$ | 0.55 ltr | 0.59 ltr | 0.55 ltr | 0.56 ltr | 0.56 ltr |
| SPL 2.83V | 83.7dB | 83.7dB | 83.2dB | 82.9dB | 86.5dB |
| $X_{MAX}$ | 2.0mm | 2.0mm | 2.0mm | 2.0mm | 2.0mm |

into LEAP, a 60 $in^3$ Butterworth alignment and a 10 $in^3$ Chebychev type alignment. Figure 2 displays the results for the Wavecor full-range driver in the two sealed box simulations at 2.83V and at a voltage level high enough to increase cone excursion to Xmax + 15% (2.3mm). This produced a F3 frequency of 133Hz with a box/driver Qtc of 0.72 for the 60 $in^3$ sealed enclosure and –3dB = 205Hz with a Qtc = 1.0 for the 10 $in^3$ simulation. Increasing the voltage input to the simulations until the maximum linear cone excursion was reached resulted in 92.5dB at 6V for the larger sealed enclosure simulation and 100.5dB with a 13.5V input level for the smaller sealed enclosure (see Figs. 3 and 4 for the 2.83V group delay curves and the 6/13.5V excursion curves).

Klippel analysis for the Wavecor 2.75" full-range (our analyzer is provided courtesy of Klippel GmbH), and testing performed by Pat Turnmire, Red Rock Acoustics, produced the Bl(X), Kms(X), and Bl and Kms symmetry range plots given in Figs. 5-8 . The Bl(X) curve (Fig. 5 ) is relatively broad and symmetrical, especially for a short Xmax 2.75" diameter driver. Looking at the Bl symmetry plot (Fig. 8 ), this curve shows a trivial 0.11mm coil-in offset at the rest position that decreases to 0.09mm at the physical 2.0mm Xmax of the driver.

Figures 7 and 8 show the Kms(X) and Kms symmetry range curves for the Wavecor full-range driver. The Kms(X) curve is definitely very symmetrical, and has a very minor forward (coil-out) offset of less than 0.5mm at the rest position. FR070 displacement limiting numbers calculated by the Klippel analyzer were XBl at 82% Bl = 1.7mm and for XC at 75% Cms minimum was 1.1mm, which means that the compliance is the most limiting factor for the prescribed distortion level of 10%.

Figure 9 gives the inductance curve Le(X) for the FR070WA01. Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area; however, the FR070 inductance stays mostly constant as the coil moves in due to the copper shorting ring. The inductance variation is only 0.05mH from the in and out Xmax positions, which is very good.

Next I mounted the FR070 in an enclosure which had a

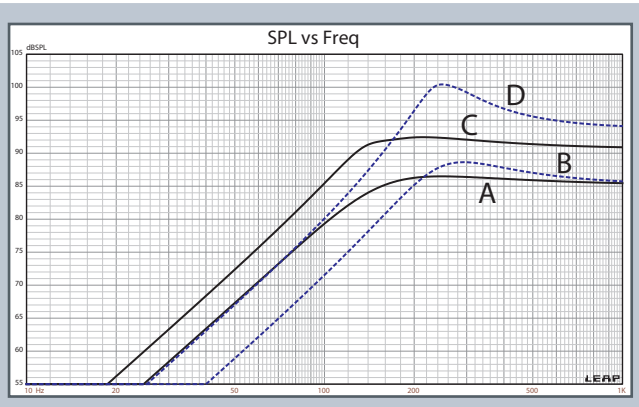


FIGURE 2: FR070WA01 computer box simulations (A = sealed 1 at 2.83V; B = sealed 2 at 2.83V; C = sealed 1 at 6V; D = sealed 2 at 13.5V).

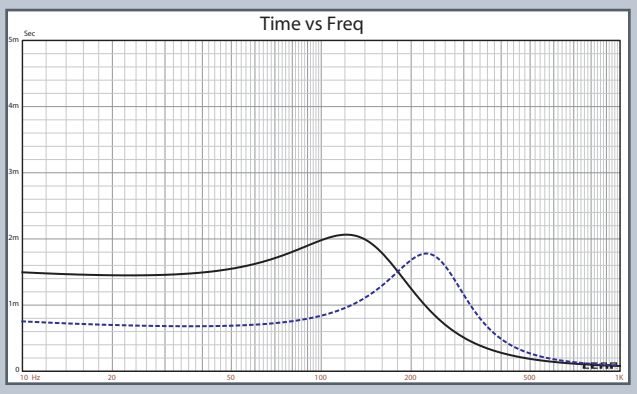


**FIGURE 3: Group delay curves for the 2.83V curves in *Fig. 2*.**

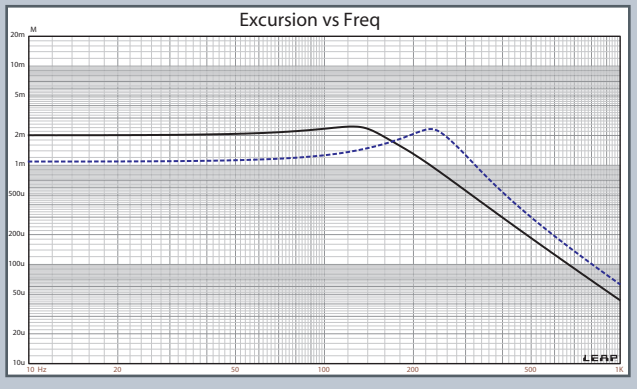


**FIGURE 4: Cone excursion curves for the 6/13.5V curves in *Fig. 2*.**

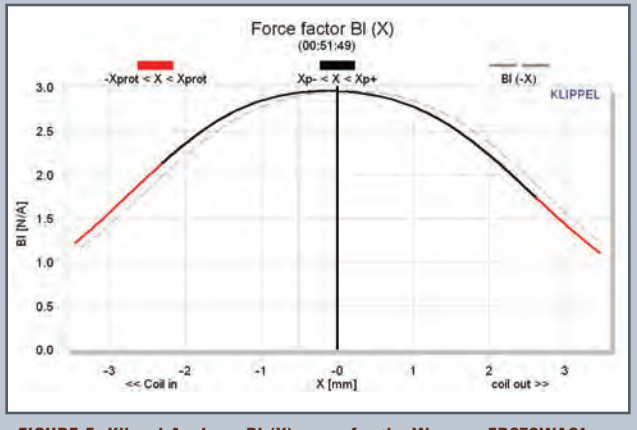


**FIGURE 5: Klippel Analyzer Bl (X) curve for the Wavecor FR070WA01.**

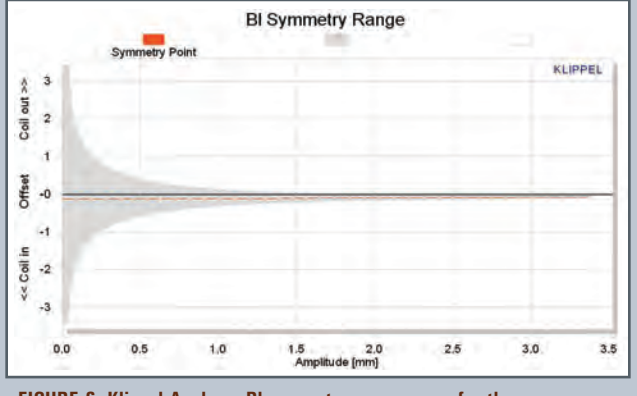


**FIGURE 6: Klippel Analyzer Bl symmetry range curve for the FR070WA01.**

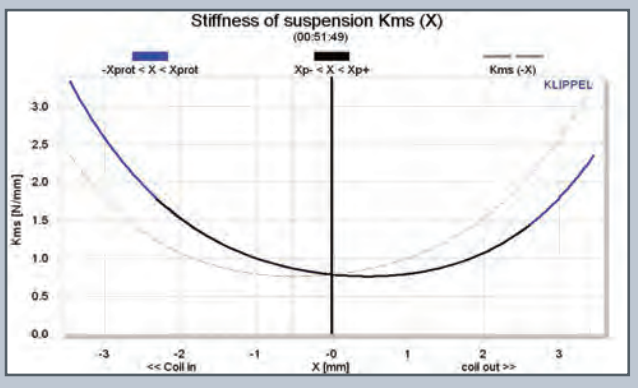


**FIGURE 7: Klippel Analyzer mechanical stiffness of suspension Kms (X) curve for the Wavecor FR070WA01.**

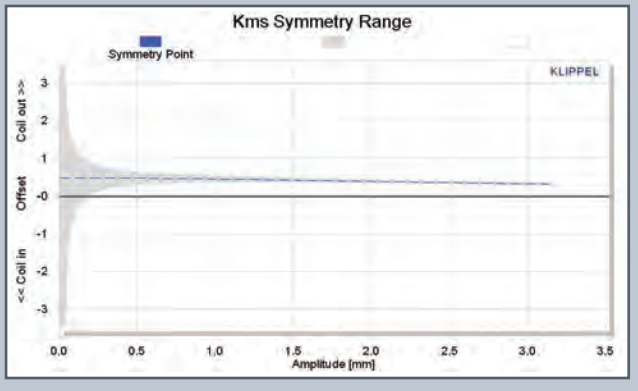


**FIGURE 8: Klippel Analyzer Kms symmetry range curve for the FR070WA01.**

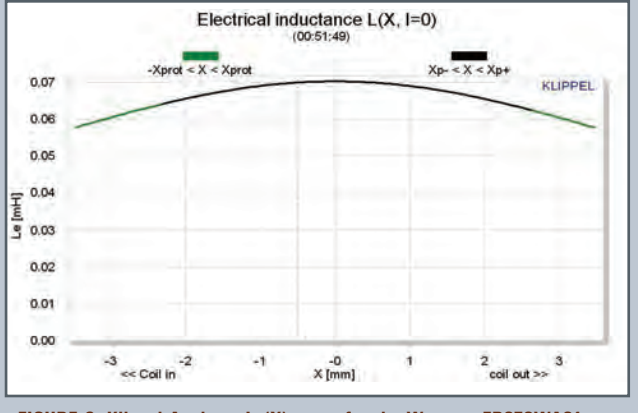


**FIGURE 9: Klippel Analyzer Le(X) curve for the Wavecor FR070WA01.**

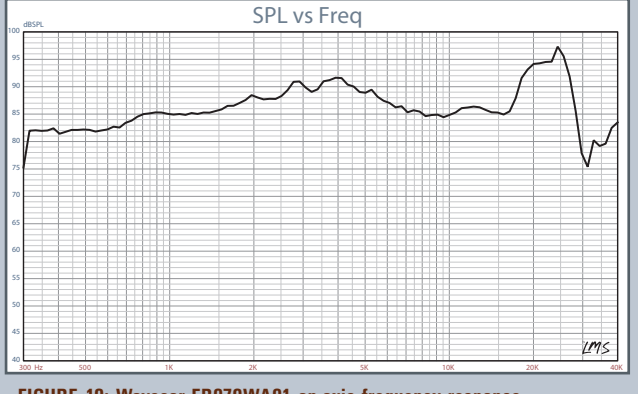


**FIGURE 10: Wavecor FR070WA01 on-axis frequency response.**

9' × 4' baffle and was filled with damping material (foam) and then measured the transducer on- and off-axis from 300Hz to 40kHz frequency response at 2.83V/1m using the LinearX LMS analyzer set to a 100-point gated sine wave sweep. Figure 10 gives the on-axis response indicating a smoothly rising response to about 4kHz, decreasing 7dB to 10kHz and some breakup peaking at 25kHz the highpass rolloff. However, it definitely has a response on-axis out to 25kHz as advertised!

Figure 11 displays the on- and off-axis frequency response at 0, 15, 30, and 45°. The rolloff at 30° off-axis is almost as good as a 1 dome, so I expect the full-range fidelity of this driver to be quite good. The last SPL measurement is given in Fig. 12 , the two-sample SPL comparison for the 2.75" Wavecor driver, showing a close match to within less than 1dB throughout the operating range.

For the remaining series of tests, I employed the Listen Inc. SoundCheck analyzer with the ¼" SCM microphone and power supply (courtesy of Listen Inc.) to measure distortion and generate time frequency plots. For the distortion measurement, I mounted the Wavecor woofer rigidly in free-air, and set the SPL to 94dB at 1m (4.1V) using a noise stimulus, and then measured the distortion with the microphone placed 10cm from the dust cap. This produced the distortion curves shown in Fig. 13 . I then used SoundCheck to get a 2.83V/1m impulse response for this driver and imported the data into Listen Inc.'s SoundMap Time/Frequency software. The resulting CSD waterfall

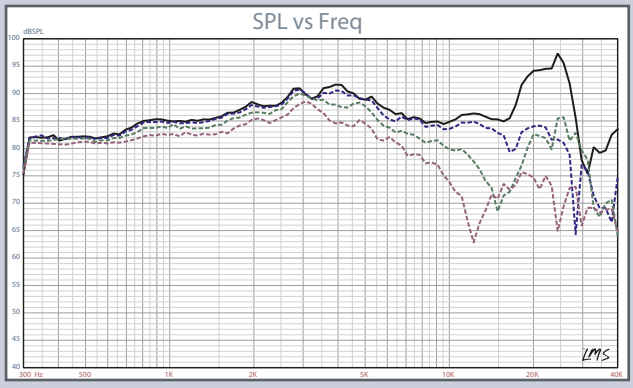


FIGURE 11: Wavecor FR070WA01 on- and off-axis frequency response.

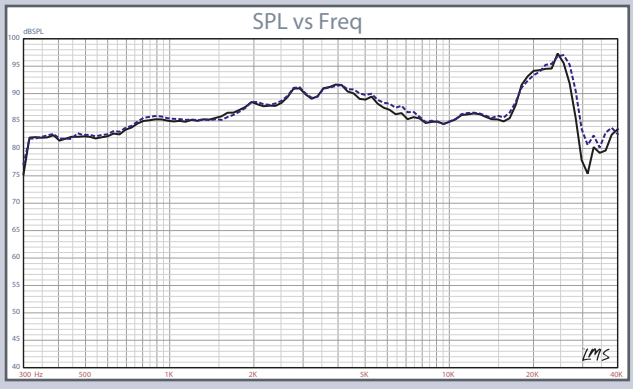


FIGURE 12: Wavecor FR070WA01 two-sample SPL comparison.

plot is given in Fig. 14 and the Wigner-Ville (for its better low-frequency performance) plot in Fig. 15 . While the intended application for this 2.75" full-range driver is multimedia and lifestyle speakers, I suggest that this would make a great driver for line source applications. For more on this well-crafted driver, visit www.wavecor.com.



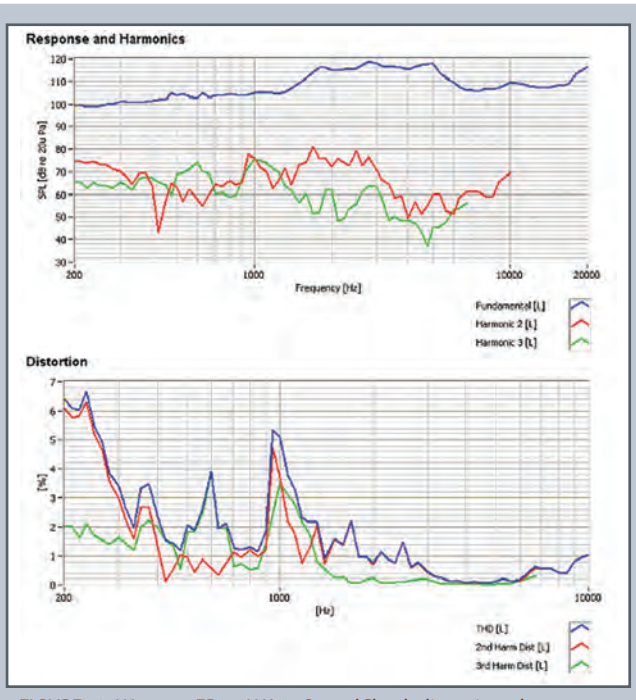


FIGURE 13: Wavecor FR070WA01 SoundCheck distortion plot.

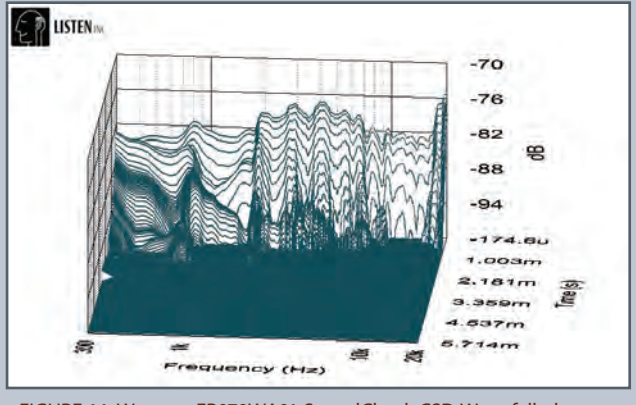


FIGURE 14: Wavecor FR070WA01 SoundCheck CSD Waterfall plot.

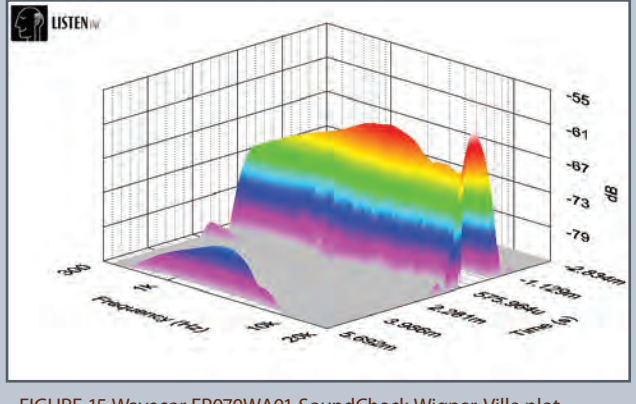


FIGURE 15 Wavecor FR070WA01 SoundCheck Wigner-Ville plot.