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VOICE COIL

THE PERIODICAL FOR THE LOUDSPEAKER INDUSTRY

IN THIS ISSUE

Industry News & Developments

By Vance Dickason

Happy 27th Birthday *Voice Coil*!

November 2013 marks the beginning of *Voice Coil*'s 27th year as an information resource for the loudspeaker industry. *Voice Coil* magazine resulted from a conversation I had with Ed Dell following Audio Amateur's publication of the *Loudspeaker Design Cookbook*, 3rd edition. (Sadly Ed passed in February of this year. You can read his memorial in *Voice Coil*'s May 2013 issue.) Ed related his concept to create a publication that would become the loudspeaker industry's "information super highway." Needless to say, I considered it not only an outstanding concept for a new publication, but something I felt the industry greatly needed and would happily support. Obviously, after 26 years, we were right to move forward with the publication. Ed came up with the *Voice Coil* name, and as they say, the rest is history.

From the first issue in November 1987 until June of 1995, *Voice Coil* was a monthly subscription-based black-and-white, four-page newsletter I wrote with no additional contributors and no advertising. However, the June 1995 issue jumped to 20 pages of four-color printing on glossy paper. (*Voice Coil* is currently about 32–48 pages each month!) The magazine is now advertiser driven and is free for qualified subscribers. *Voice Coil* is also available as an Internet-delivered subscription.

In addition to the change in printing, distribution, and digital delivery, *Voice Coil* often features guest contributors including Jim Croft, Charlie Hughes, Mike Klasco, Wolfgang Klippel, Steve Mowry, Steve Temme, Pat Turnmire, and many others.

Support has come from some of the industry's finest engineers and through the generosity of analyzer/software manufacturers (e.g., Klippel GmbH, LinearX, and

An 18” Woofer and a 6.5” Midrange

By Vance Dickason

This month Celestion’s 18” pro sound woofer and MAG’s 6.5” pro sound midrange are put to the test.

The CF18VJD

In the September 2013 *Voice Coil*, I examined the AN3510 driver, a Celestion 3.5” line source driver. This month, I am going to the extreme opposite with a new 18” Celestion CF18VJD pro sound woofer. As a former professional musician, I’ve always been a big Celestion fan. I still own a Vox AC-30 that contains a pair of the legendary 12” Celestion Blues. If you are not familiar with Celestion’s history (it’s a rather interesting story), you may want to read about the company in, “Two Pro Sound Drivers and a Home Audio Midwoofer,” (*Voice Coil*, September 2013).

Designated as a woofer, the CF18VJD is a high-power handling woofer rated at 1,600 W_{RMS} (AES standard) and weighs a hefty 50.6 lb (see **Photo 1**). The CF18VJD’s features include a proprietary seven-spoke cast aluminum frame. However, Celestion’s approach for this model does not include venting below the spider mounting shelf at the top of the front plate, a common feature built into high-power handling woofer frames. Instead, Celestion uses a vented front plate that exhausts toward a series of peripheral vents located on the top of the back plate.

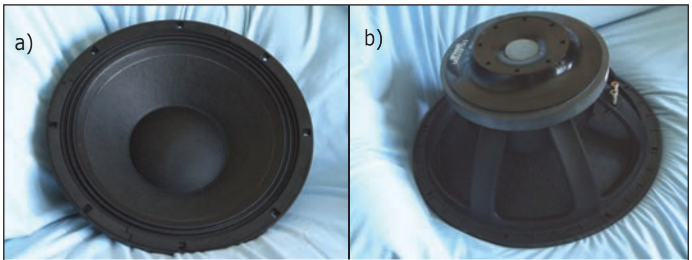

Photo 1: Celestion’s CF18VJD woofer is shown in a top (a) and bottom (b) view.

The cone assembly consists of an 18” carbon and Kevlar-loaded paper cone and a large 6.5” diameter carbon and Kevlar-loaded paper dust cap. Suspension is provided by a three-roll M-shaped coated (sealed) cloth surround in conjunction with two 7.5” diameter flat treated-cloth spiders (dampers), which I would assume are mounted back to back to cancel out odd-order nonlinearity. All this is driven by a 5” (125-mm) diameter high-temperature non-conducting voice coil former wound with a two-layer inside/outside round copper wire winding. The voice coil is terminated to a pair of color-coded chrome push terminals.

I immediately noticed the CF18VJD’s massive ferrite finite element analysis (FEA) optimized motor assembly. This consists of a single 25-mm × 270-mm ferrite magnet sandwiched between a black coated 250-mm diameter front plate that forms the 12-mm gap area and a 250-mm diameter × 40-mm high-milled shaped T-yoke, also black coated. Besides the eight 9-mm diameter peripheral vents in the back plate for cooling and transmitting air from the vented front plate, the T-yoke also incorporates a 52-mm pole vent. Also included in the motor structure are a set of dual shorting rings (Faraday shields) to reduce flux modulation and distortion.

I clamped the CF18VJD driver to a rigid test fixture in free air at 1, 3, 6, 10, 15, 20, and 30 V. Then, I used the LinearX LMS and VIBox to produce voltage and admittance (current) curves. I use a procedure that attempts to achieve the third-time constant on each sweep, so the LMS oscillator is turned on for a progressively increasing time period between sweeps.

Following established Test Bench test protocols, I no longer use a single added mass measurement. Instead, I used the actual measured cone assembly weight that Celestion provided at my request.

Next, I post-processed the 14 550-point stepped sine wave sweeps for each sample and divided the voltage curves by the current curves to derive the impedance curves. Then, I calculated the phase (LMS is a single-channel analyzer and does not measure phase, but it does have a highly accurate phase-proprietary calculation methodology). Next, I imported them along with the accompanying voltage curves into the LEAP 5 Enclosure Shop software. This is a more time consuming process than the usual low-voltage, small-signal impedance curve technique used to derive Thiele-Small (T-S) parameters. The reason for this is that the LEAP 5 LTD transducer model methodology results in a more accurate prediction of excursion at high voltage levels, which is one of the LEAP 5 software’s real fortes.

Because most T-S data provided by OEM manufacturers is produced using either a standard modeling method or the LEAP 4 TSL model, I also created a LEAP 4 TSL model using the 1-V free-air curves. The complete data set, the multiple voltage impedance curves for the LTD model, and the 1-V impedance curves for the TSL model were selected in the Transducer Derivation menu in LEAP 5 and created the parameters for the computer enclosure simulations. **Figure 1** shows the woofer 1-V free-air impedance curve. **Table 1** compares the LEAP 5 LTD and TSL data

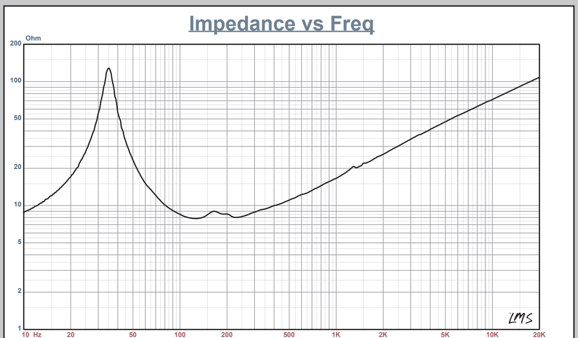

Figure 1: Celestion CF18VJD woofer free-air impedance plot

	TSL Model		LTD Model		Factory
	Sample 1	Sample 2	Sample 1	Sample 2	
F_S	34.9 Hz	38.4 Hz	34.2 Hz	34.4 Hz	34.3 Hz
R_{EVC} (series)	5.94	5.95	5.94	5.95	5.98
Sd	0.115	0.115	0.115	0.115	0.113
Q_{MS}	7.85	7.26	7.84	7.69	5.15
Q_{ES}	0.36	0.39	0.35	0.38	0.36
Q_{TS}	0.34	0.36	0.33	0.34	0.34
V_{AS}	160.1 ltr	134.4 ltr	167.9 ltr	166.6 ltr	150.6 ltr
SPL 2.83 V	94.7 dB	94.8 dB	94.7 dB	94.3 dB	97 dB
X_{MAX}	9 mm	9 mm	9 mm	9 mm	9 mm

Table 1: Celestion CF18VJD woofer comparison data

and Celestion factory parameters for both CF18JVD samples.

Parameter measurement results for the CF18VJD showed reasonable agreement with the Celestion data, but the sensitivity data I derived was 2.2 to 2.7 dB lower than the factory data. However, my sensitivity rating is derived from parameter calculation at 2.83 V.

The Celestion factory sensitivity is a physical measurement at 1 W/1 m half space in its anechoic chamber. While not absolutely identical, my parameter measurements were obviously close to the factory data. This is almost always the case when I measure pro sound products, which speaks to the excellent group of transducer engineers at these companies. Celestion is obviously no exception.

Given this, I used the LEAP LTD parameters for Sample 1 to set up two computer enclosure simulations. This included two vented alignments, a 2.3 ft^3 QB3 box alignment with

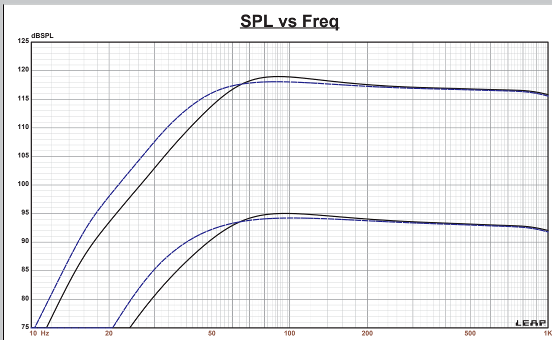

Figure 2: Celestion CF18VJD computer box simulations (black solid = vented 1 at 2.83 V; blue dash = vented 2 at 2.83 V; black solid = vented 1 at 50 V; blue dash = vented 2 at 50 V)

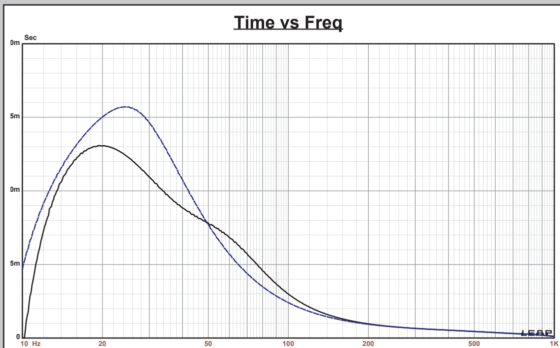

Figure 3: Group delay curves for the 2.83-V curves shown in Figure 2

15% fiberglass fill material tuned to 40 Hz and an extended bass shelf (EBS) alignment in a 3.9 ft^3 vented enclosure with 15% fiberglass fill material and tuned to 34 Hz.

Figure 2 shows the enclosure simulation results for the CF18VJD in the QB3 and EBS vented boxes at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to X_{MAX} + 15% (10.4 mm for the CF18VJD). The simulation produced a −3 dB frequency of 55.4 Hz (−6 dB = 45.3 Hz) for the 2.3 ft^3 QB3 enclosure and F3 = 44.1 Hz (F6 = 34.9 Hz) for the 3.9-ft^3 EBS vented simulation.

Increasing the voltage input to the simulations until reaching the maximum linear cone excursion resulted in 119 dB at 50 V for the QB3 enclosure simulation and 118 dB the same 50-V input level in the larger vented box. **Figure 3** and **Figure 4** show the 2.83-V group delay curves and the 60-V excursion curves, respectively. Note that the voltage input was limited to 50 V as the X_{MAX} + 15% number was exceeded at about 20 Hz. With a 25-Hz high-pass, I could have easily driven this woofer several decibels louder for the same criteria.

The Celestion CF18VJD's Klippel analysis produced the Bl(X), K_{MS}(X), and Bl and K_{MS} symmetry range plots shown in **Figures 5–8**. Klippel provides our analyzer and Patrick Turnmire, Redrock Acoustics (SpeaD and RevSpeaD transducer software) performs the testing.

The CF18VJD's Bl(X) curve shown in **Figure 5** is nicely broad and symmetrical. **Figure 6**'s Bl symmetry plot shows a minor 0.81-mm coil-in offset at the rest position and remains nearly constant out to the driver's physical X_{MAX}, which is quite good. **Figures 7** and **8** show the Celestion CF18VJD's K_{MS}(X) and K_{MS} symmetry range curves. The K_{MS}(X) curve is as also rather symmetrical but with some obvious forward coil-out offset. Looking at the K_{MS} symmetry range curve, the forward offset is a fairly trivial 2.8 mm at rest and stays constant throughout the operating range, which suggests a small mechanical offset in the physical parts, but it is not hearable.

The CF18VJD's displacement-limiting numbers (calculated by the Klippel analyzer) were XBl at 70% (with the Bl decreasing to 70% of its maximum value), which was greater than 9.9 mm. The crossover at 50% (compliance decreasing to 50% of its maximum value) was 6.2 mm (just beyond the physical X_{MAX}), which means for this Celestion CF18VJD, the compliance is the most limiting factor for the prescribed 20% distortion level.

Figure 9 shows the CF18VJD's inductance curve L(X). Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area unless the driver incorporates a shorting ring. The CF18VJD has a dual shorting ring configuration, which in this case doesn't do much for the inductance values, but does minimize the L(I) inductive current, which is good.

I dispensed with the SPL measurements for the CF18VJD, mostly because I don't keep 18" or 21" size cabinets in my inventory of test fixtures. However, **Figure 10** provides the factory SPL curve.

Since I did not perform SPL measurements, I moved on to the last group of tests. I used the Listen SoundCheck AmpConnect analyzer, SC-1 microphone and SoundConnect power supply (courtesy of Listen) to measure distortion. Because I did not have an available enclosure, I did not use Listen's SoundMap software for time-frequency presentations.

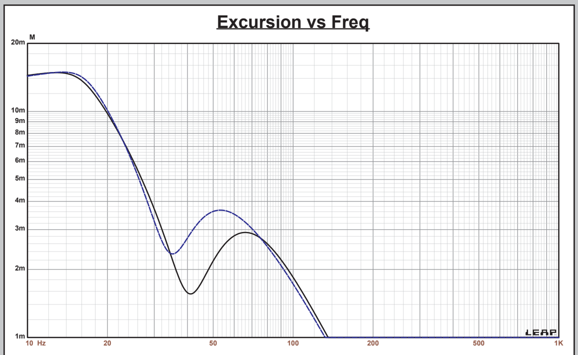

Figure 4: Cone excursion curves for the 50-V curves shown in Figure 2

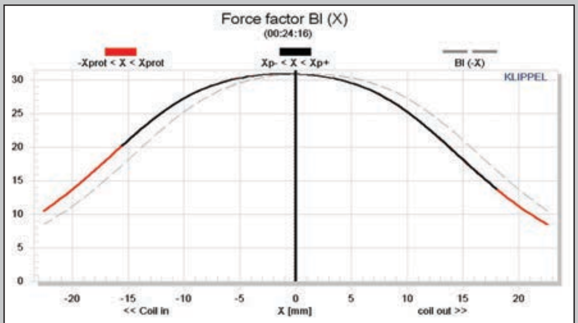

Figure 5: Group delay curves for the 2.83-V curves shown in Figure 4

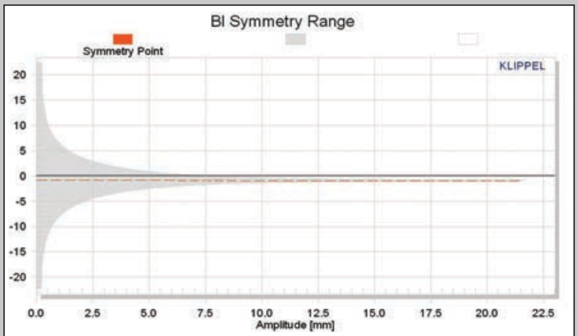

Figure 6: Klippel analyzer Bl symmetry range curve for the Celestion CF18VJD

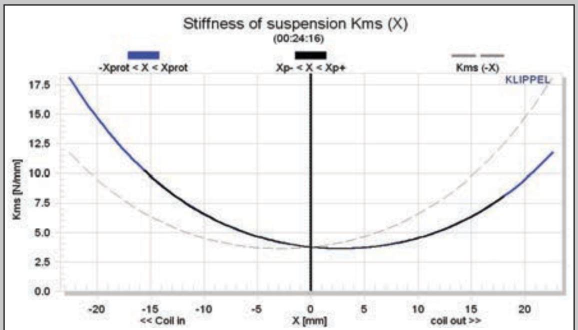

Figure 7: Klippel analyzer mechanical stiffness of suspension K_{MS} (X) curve for the Celestion CF18VJD

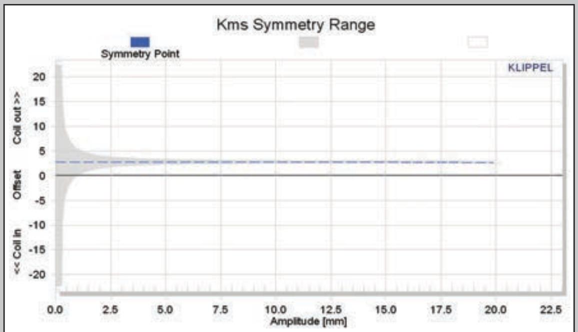

Figure 8: Klippel analyzer K_{MS} symmetry range curve for the Celestion CF18VJD

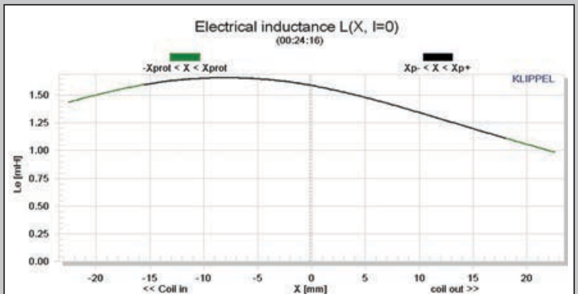

Figure 9: Klippel analyzer L(X) curve for the Celestion CF18VJD

To set up for the distortion measurement, I mounted the woofer rigidly in free-air and used a noise stimulus (SoundCheck has a software generator and SPL meter as two of its utilities) to set the SPL to 104 dB at 1 m. Then, I measured the distortion with the Listen microphone placed 10 cm from the dust cap. **Figure 11** shows the CF18VJS's distortion curves.

Celestion has delivered a well-designed and extremely robust 18″ for pro-sound woofer for public address (PA) applications. The CF18VJD also has a number of fairly unique proprietary features. For more information on this and other pro sound products from Celestion, visit www.celestion.com.

The M0610

This next submission comes from a company new to Test Bench, MAG Professional Loudspeakers, which is located in Bila Tserkva, Ukraine. (Russian names are easy to pronounce in Russian, it's phonetic, but nearly impossible figure out in their anglicized incarnation.) MAG was founded in 1989 as a post-Perestroika cooperative venture, specializing in cone

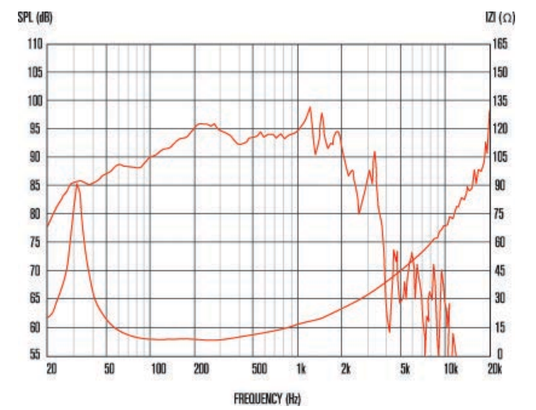

Figure 10: Celestion CF18VJD Factory on-axis frequency response

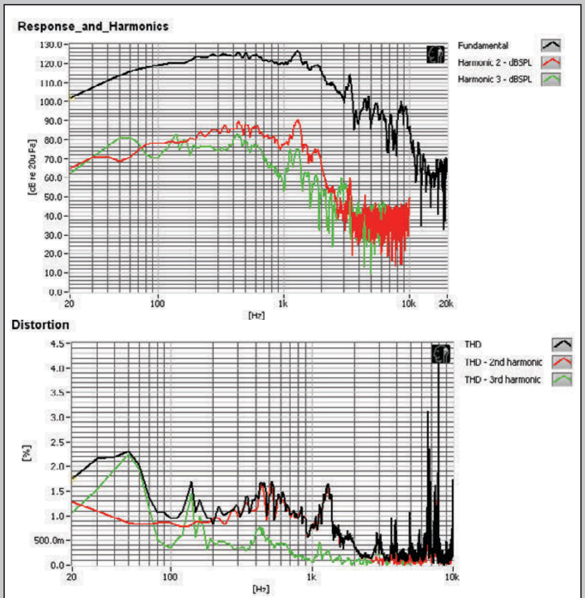

Figure 11: Celestion CF18VJD SoundCheck distortion plot

Photo 2: MAG Company factory headquarters in the Ukraine

Photo 3: MAG's M0610 pro sound midrange driver

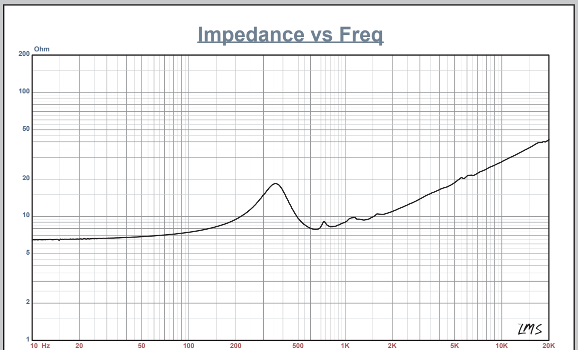

Figure 12: MAG M0610 free-air impedance plot

speaker production and repair. The main production facility was built a year later, in 1990 (see **Photo 2**).

The company's primary products were ferrite magnets, which MAG continues to produce. In 1993, MAG exported its first batch of loudspeakers abroad. Since then, MAG has been shipping its products to Israel, Poland, Belarus, the Russian Federation, Moldova, Romania, and Germany. Since 1995, MAG transducers have been assembled exclusively using components from Dr. Kurt Mueller GmbH and U-Sonics in Malaysia.

In 2006, MAG began manufacturing speaker systems that range from small mobile sound systems and tiny PA speakers to large-scale touring front-of-house (FOH) speakers and line arrays. MAG professional transducers include a range of cone loudspeakers with sizes from 6″ to 21″, plus 1″, 1.4″, 1.5″, and 2″ high-frequency drivers and coaxial drivers. Besides manufacturing, MAG provides services in audio and lighting development, installation, and maintenance.

MAG currently has 120 employees and a 30,000 ft^2