Technical Note Volume 1 Number 34

JBL's New Differential Drive® Transducers for VerTec® Subwoofer Applications:

Introduction and Prior Art:

JBL's 18-inch 2242H low frequency transducer represents the culmination of a design philosophy that dates back to the early days of the company. The original Alnico V magnet material was eventually replaced by ferrite material, and the motor structure now incorporates both SFG (Symmetrical Field Geometry) and VGC (Vented Gap Cooling). All moving parts have at various times have been improved in terms of power handling and reliability, and adhesives have undergone radical improvements. After benefiting from incremental changes, the 2242H as it stands today is a workhorse for sound reinforcement applications, and its 800-watt continuous pink noise power rating places it in the top ranks of that market.

Unlike installed-venue applications where systems are permanently set in place and where the sheer mass of a system is of little concern, the tour sound industry carries a large weight penalty. Because of this requirement, tour sound systems have been designed to be both rugged and as low in weight as JBL can design them. This is especially true for line array applications, where there may be large numbers of loudspeaker enclosures in a single array. The global rise in popularity of the line array has required us to re-examine our basic technology, and one result of this was the Differential Drive motor structure.

The Rise of Differential Drive:

Light-weight Differential Drive transducers were introduced by JBL in the mid-90s to take advantage of size and weight scaling and to achieve high performance with highenergy neodymium magnets. The technology was first applied to the EON series of portable loudspeakers and later to high-efficiency midrange transducers for the horn-loaded HLA tour sound system.

The new magnets (technically NdFeB, or neodymium-iron-boron sintered structures), have a very high value of *remanent induction*, and as a result only relatively small amounts of the material are required to produce a desired magnetic field strength in the gap. This translates directly into small light-weight magnetic structures. The high remanent induction also permits the transducer engineer to design a motor structure that has two gaps in magnetic series in which two coils can be placed, while at the same time retaining a sufficiently high magnetic flux for both coils. Details of the basic design are given in JBL Technical Note Volume 1 Number 33 (copy available on-line at *www.jblpro.com*).

The primary result using this new material has been a much smaller coil assembly producing twice the mechanical force of a single coil. In fact, a pair of 2-inch coils operating in this manner would be equivalent to a single 4-inch coil, provided magnetic flux density, total amount of conductor in the gap, and displacement limit are all identical.

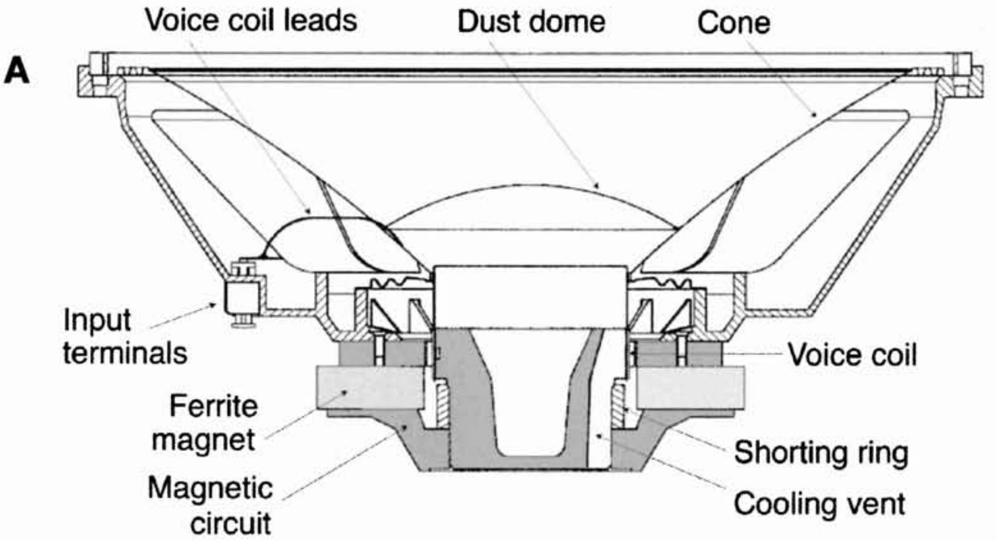
A Family of Transducers Designed Specifically for Subwoofer Applications:

Figures 1A and 1B show section views of 2242H and JBL's new 2269H Ultra Long Excursion drivers at the same scale. Note that both have 4-inch voice coils, but with its dual coil arrangement, the 2269 has *twice* the voice coil length immersed in an equivalent magnetic field.

The cone in the 2269 has greater mass than that in the 2242, and the total peak-to-peak stroke is longer, as is the linear portion of the magnetic field. Figure 2 shows the 2242 versus the 2269 pressure output with 80 watts fed to each transducer at a distance of 1 meter. As seen in the figure, the 2269 has 2 to 3 dB lower response in the 80 to 250 Hz region than the 2242, but has increasing response below 80 Hz. At 30 Hz, the 2269 delivers an impressive 6 dB more output than the 2242 for the same input power!

Output power alone is not the only aspect of subwoofer performance to be considered. Overall system fidelity is also a key aspect, especially in music reinforcement applications. Considering distortion, the data in Figure 3A shows that at 30 Hz the level of second and third harmonic distortion for the 2269 is about 35 dB lower than the fundamental. As seen in Figure 3B, for the 2242 the 30 Hz distortion with the same drive signal is about 15 dB lower than the fundamental. (Note that distortion levels in the graphs have been raised by 20 dB for display purposes in Figures 3A and 3B.) One

2242H Section View



2269H Section View

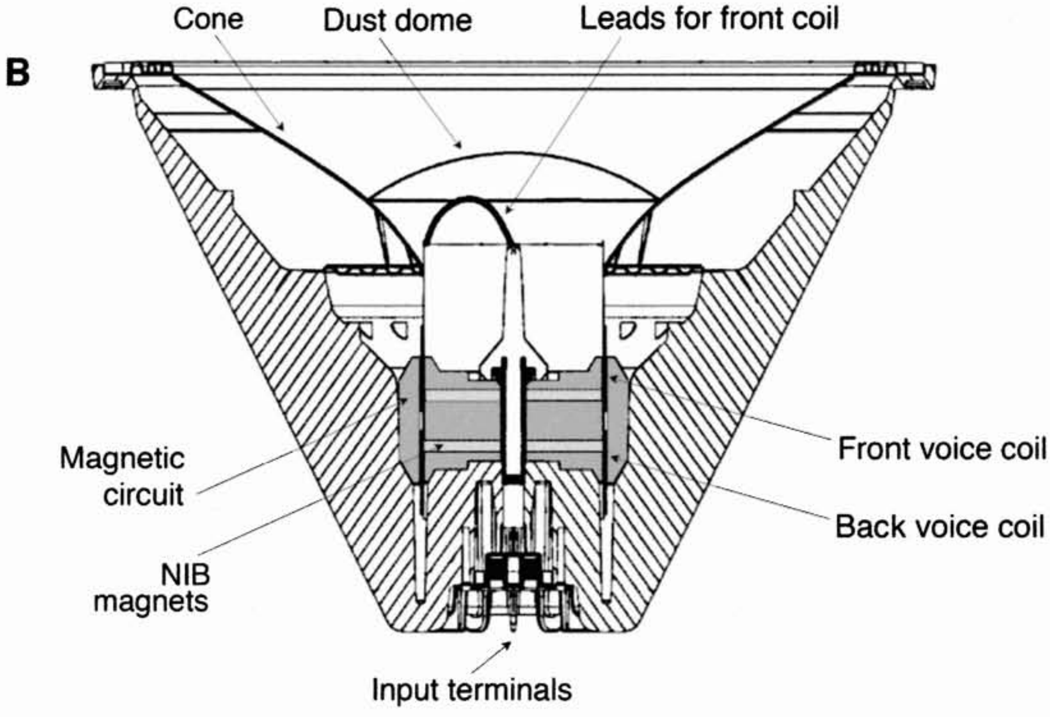


Figure 1. Section view of drivers. JBL 2242 (A); JBL 2269 (B).

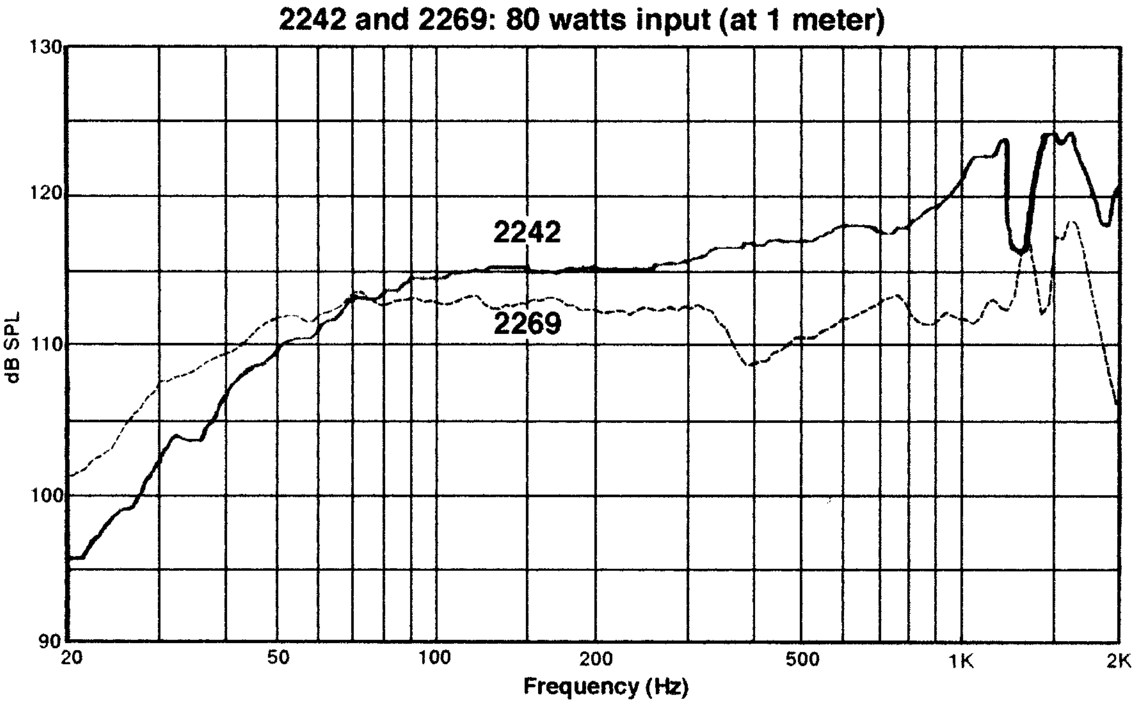


Figure 2. A comparison of on-axis output of JBL 2242H and 2269 drivers at 80 watts input.

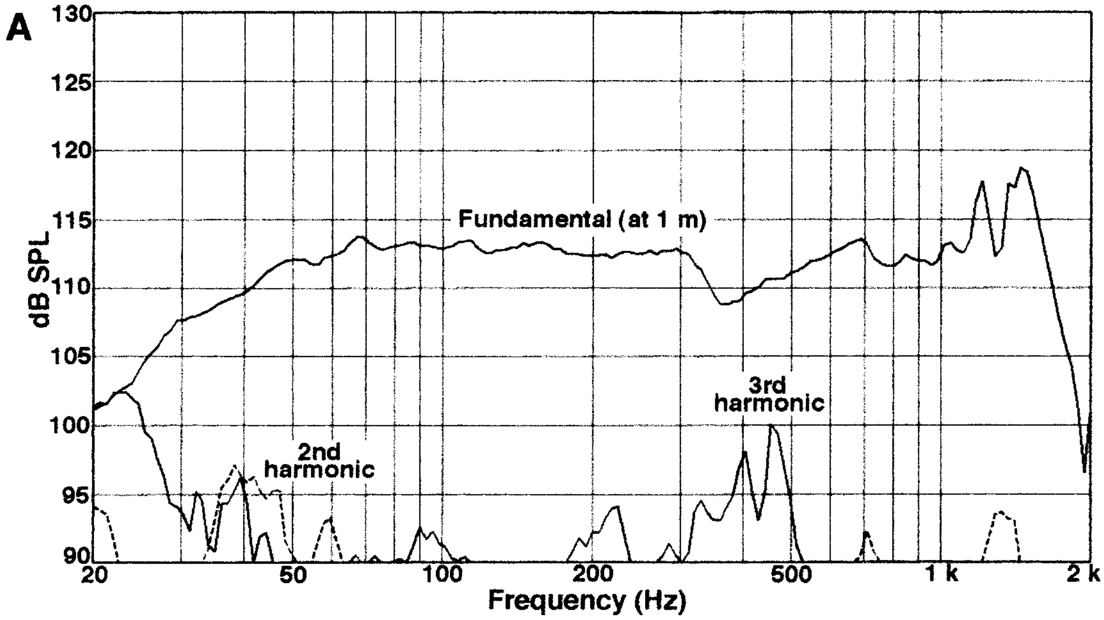
can clearly see that the 2269 has been designed primarily as a subwoofer driver for applications where it is used in the range of 20 to 25 Hz up to about 100 Hz.

Figure 4 shows the relative output levels of each of these drivers when normalized for the same amount of total harmonic distortion at 30 Hz. Note that at 30 Hz the 2269 has a clear 10-dB advantage over the 2242.

VerTec Subwoofer System Applications:

All VerTec subwoofer models feature Differential Drive transducer technology and have been specifically designed for use with VerTec VT4887A, VT4888, and VT4889 full range line array elements.

The VerTec VT4880 subwoofer, a full-size arrayable system element, uses the 2258 Differential Drive transducer (a modern dual coil version of the 2242), while the more recent model 2269 driver, shown in Figure 1B, is used in the VT4881A compact and VT4880A full size models, both recent additions to the VerTec system product family. Figure 5A shows a section view of the 2258, while Figure 5B shows the on-axis response



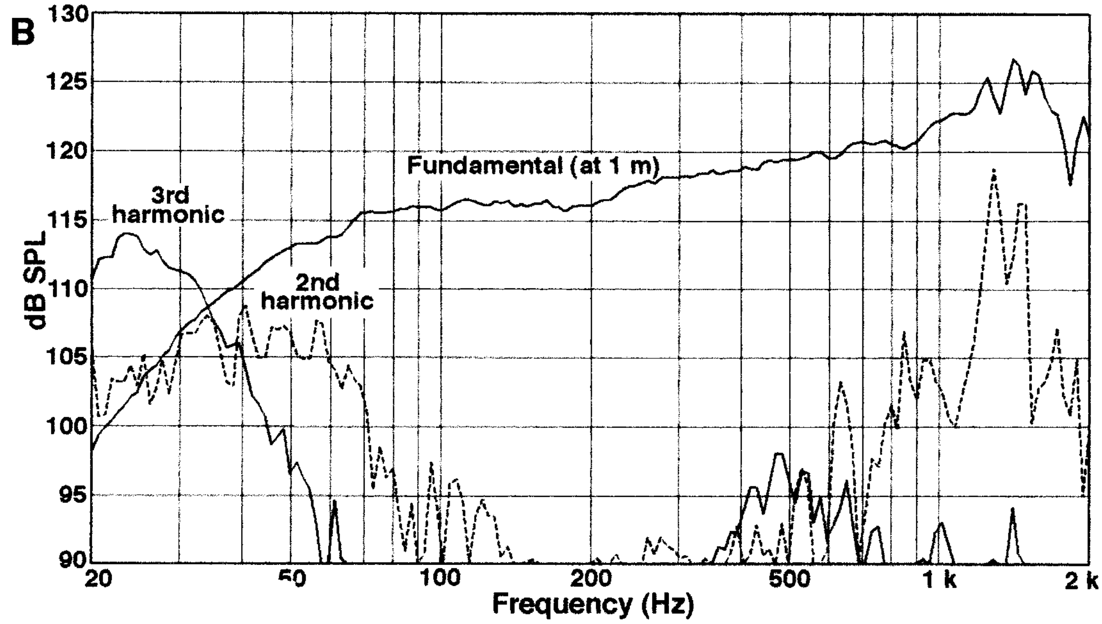


Figure 3. Fundamental and distortion response of 2269H driver at 80 watts (A); fundamental and distortion response of 2242H driver at 80 watts (B). (Distortion raised 20 dB)

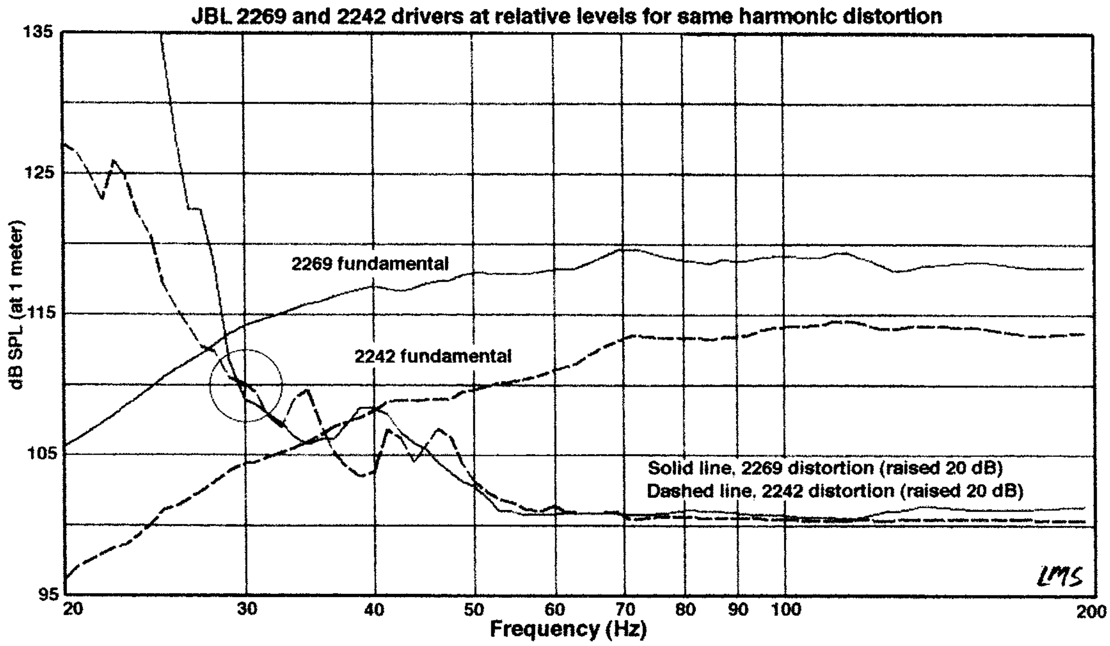


Figure 4. A comparison of output levels of JBL 2242H and 2269H drivers at the same distortion level.

at 10 dB below rated power along with 2nd and 3rd harmonic distortion (As previously noted, the distortion components have been raised 20 dB for display purposes.)

Basic Design Parameters:

Table 1 shows selected Thiele-Small parameters for the 2242, 2269, and the 2258 drivers. The 2242 and 2269 have 4-inch voice coils while the 2258 has 3-inch coils.

T-S parameters	2242:	2258:	2269:
Moving mass:	158 grams	168 grams	294 grams
Q_T:	0.275	0.36	0.36
X_{MAX}:	9 mm	10 mm	19 mm
AES Rated power:	800 watts	1200 watts	2000 watts
Free-air resonance:	35 Hz	33 Hz	28 Hz

Table 1. Properties of three 18-inch low frequency drivers.

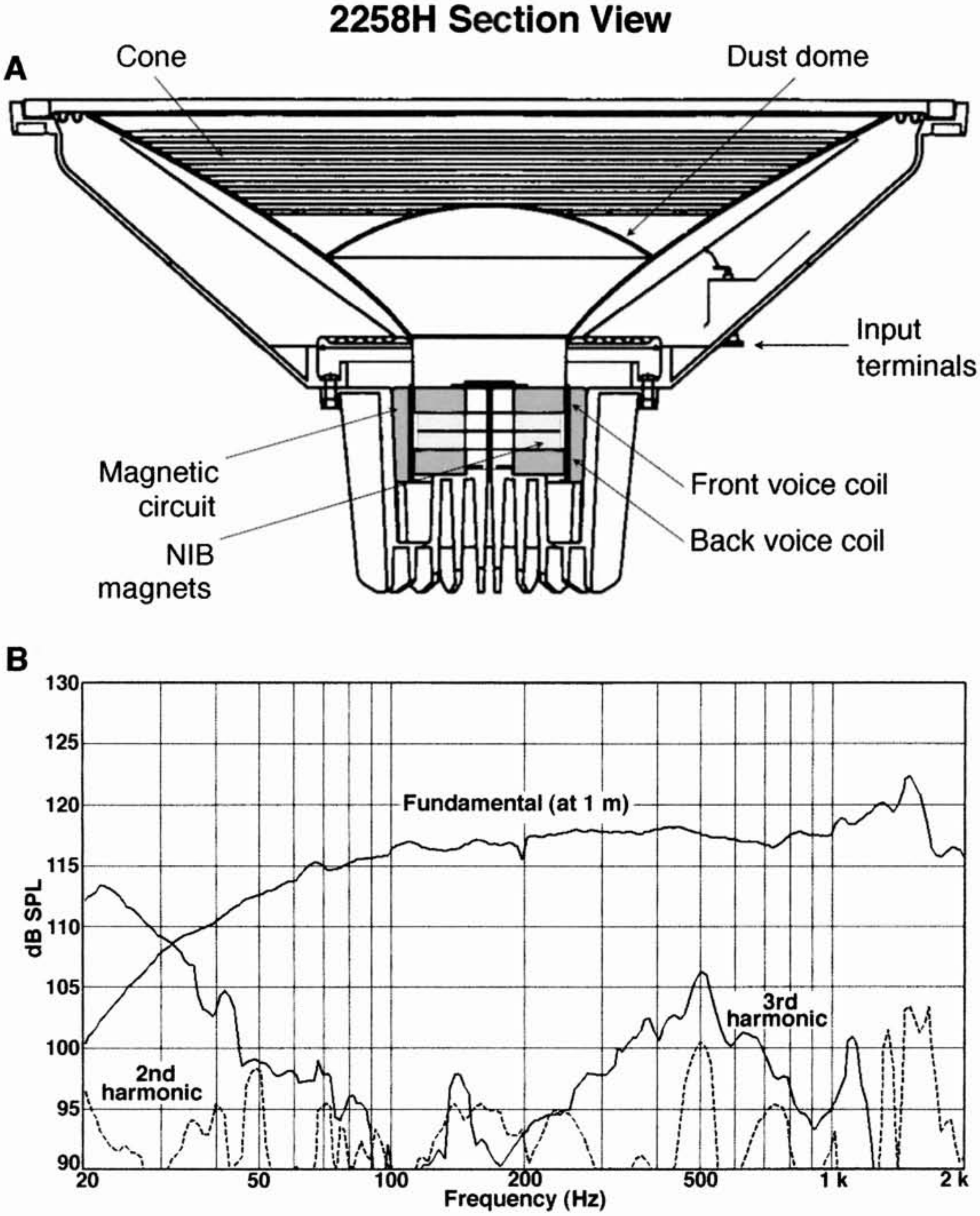


Figure 5. Section view of the JBL 2258H driver (A); fundamental and distortion response at 80 watts (B). (Distortion raised 20 dB)

The value of Q_T indicates the degree of damping in the overall electroacoustical performance of a driver. A lower value of Q_T indicates a *higher* degree of damping, while a higher value indicates a *lower* value of damping. For subwoofer applications, we want to increase the driver's low frequency output without raising the level of its driving signal, and increasing Q_T is one direct way of doing this.

The value of x_{MAX} indicates the maximum amount of linear displacement (on one side of the rest position) that the driver can safely accommodate. In subwoofer design we need as much linear displacement capability as we can get in order to achieve high levels at very low frequencies. The difference between the 2258 and 2269 drivers is almost double the linear displacement – a significant design breakthrough.

The rated power handling capability of the 2269 is 1.5 times that of the 2258, accounting for a 2-dB increase in output capability, relative to the 2258.

The lower free-air resonance of the 2269 relative to the 2258 contributes to a lower tuning frequency alignment for a given enclosure volume – an important factor in maintaining a workable enclosure size.

All of these factors, and others, play off against one another in the actual design process, and the designer's primary job is to optimize all of the trade-offs.

VT4880 and VT4880A System Performance Differences:

Response curves of the two dual 18-inch models are shown in Figure 6, where the bold curve shows the response of the VT4880 and the dashed curve shows that of the VT4880A. For line array applications, subwoofers are normally crossed over at about 80 Hz, and the increase in low frequency response smoothness and extension of the A-version is readily apparent.

It should be noted that the VT4880 and VT4880A both use the same-sized enclosure, and the interior parameters of the central port aperture are identical.

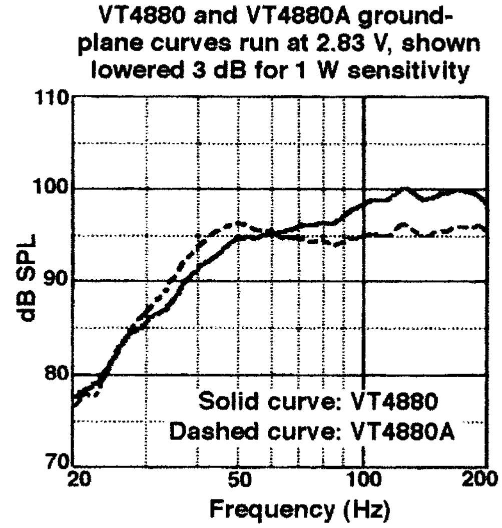


Figure 6. A comparison of VT4880 and VT4880A system fundamental output over the frequency decade from 20 to 200 Hz. (Ground plane measurements adjusted for 1-watt sensitivity)

Compared to the VT4880, the mechanical and acoustical differences are:

	VT4880:	VT4880A:
Frequency range (−10 dB):	26 - 160 Hz	25 - 160 Hz
On-axis response (±3 dB):	28 - 75 Hz	28 - 120 Hz
Sensitivity (1 W @ 1 m):	98 dB	95 dB
Nominal impedances:	2 x 8 ohms	2 x 8 ohms
Continuous power rating:	2400 watts	4000 watts

Table 2. Properties of VerTec VT4880 and VT4880A models

However, frequency range and response information given above does not tell the whole story. With 2269H woofers, when arrayed, the VT4880A makes a much stronger statement between 20 - 40 Hz than does the VT4880, and it can be driven harder (with more power applied), effectively boosting the "foundation octave effect" even more than what would be observed on a side-by-side enclosure or group of enclosures loaded with 2258H woofers.

If both 2258-loaded and 2269-loaded enclosures are driven with the same bandpass signal (to 80 Hz) at moderate levels, the enclosure loaded with 2269H drivers will appear louder due to increased power in the first octave. At the same time, if the subwoofer's low pass filter settings are raised (above 80 Hz to 100 Hz, for example), the enclosure loaded with 2258H's will seem to get louder or "punchier" at moderate levels due to their increased driver sensitivity above 80 Hz, as compared to the results observed with the 2269H's. As significantly more power is applied to each system, the VT4880A will once again appear to be "fuller" or louder, due to its ability to generate sustained high-volume air movements at higher power levels. At the same drive level the VT4880 enclosure will begin to exhibit power compression, and cone travel mechanical limits will become evident.

In summary, 2269 Ultra Long Excursion woofers mounted in VT4880 enclosures will work very well, essentially the same as in VT4880A enclosures. The VT4880 and VT4880A have different frequency response profiles and sonic characteristics, providing system designers flexibility and options when determining what kind of subwoofer and low bass performance characteristics may be desired for specific musical reasons. The user now has the choice between added "punch" above 60 Hz or low frequency extension below 60 Hz, as needed.