Technical Notes Volume 1, Number 22

JBL's New Super Vented Gap™ Maximum Output Low Frequency Transducers

Introduction:

Super Vented Gap™ (SVG™) technology is the latest development in JBL's on-going improvements in the performance of low frequency transducers. It combines the benefits of JBL's previous SFG™ and VGC™ designs with further improvements in distortion reduction and heat sinking. The result is two outstanding new transducers, the models 2227H (380 mm) and 2242H (460 mm), which provide greater maximum output capability in their respective performance classes than previous JBL transducers.

Technology Review:

JBL's Symmetrical Field Geometry was developed in the 1 970's primarily as a means of eliminating dc flux modulation by the signal current in the voice coil. This problem had been traditionally associated with ferrite magnets, and as the industry moved away from Alnico V magnet material, it was essential that we solve this problem. Basically, what happens in the normal ferrite structure is that the B-H curve (magnetization characteristic) of the ferrite material is such that strong program currents in the voice coil generate a magnetic field that alternately adds to and subtracts from the static permanent field of the ferrite, varying the operating point along the B-H curve.

The essence of SFG is the aluminum flux shorting ring located at the base of the pole piece. With its approximately one square centimeter cross-section area, the shorting ring has a resistance that is measured in the thousandths of an ohm. Considerable current is induced into it by transformer action involving the voice coil and the magnetic return path. The countercurrent set up in the flux ring opposes the shift in operating point in the magnet structure itself, thus lowering the distortion. Originally, as we made the transition from Alnico V to ferrite magnet material, the net result of SFG was a reduction of second harmonic distortion in JBL low frequency transducers of approximately 8 to 10 dB at low frequencies. In the new SVG designs the reduction of second harmonic distortion is in the range of 15 to 20 dB. JBL's Technical Notes Volume 1, Number 9 presents additional details on SFG.

JBL's Vented Gap Cooling was developed in the late 1980's as a means of pushing the upper envelope of performance by improving heat transfer from the voice coil. Traditionally, heat has been removed from the voice coil by radiation to the nearby top plate and pole piece, with subsequent conduction to the outside of the loudspeaker structure and removal through convection.

In VGC, air is drawn in directly from the outside through three openings in the back of the magnet structure. Air drawn into the structure passes over and around the voice coil; it is exhausted immediately on the reverse movement of the voice coil.

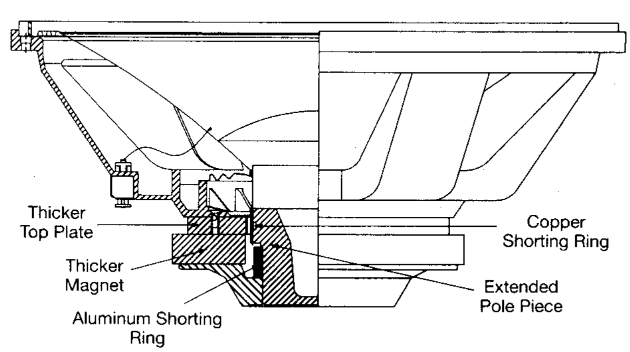
With VGC, JBL was able to make significant reductions in the amount of dynamic compression in transducers operated near their upper power limits. Here, the effect of rapid and efficient removal of heat enables the VGC transducers to reach final thermal equilibrium with less residual power compression than traditional designs, and long term improvements of 3 to 4 dB can be made. JBL's Technical Notes Volume 1, Number 18 presents more information on VGC.

Super Vented Gap Technology:

SVG incorporates and extends the improvements of SFG and VGC. The salient structural differences are shown in transducer section view in Figure 1:

1. Thicker top plate and magnet structure. These afford better heat sinking and greater flux in the gap for a higher B1 product (magnetic flux times voice coil length). This provides higher electromechanical damping and increased motor strength.

Figure 1.



2. Extended pole piece. The extension of the pole piece above and below the gap provides better axial magnetic flux field symmetry for lower distortion at high excursions. At the same time, it provides better thermal conductivity for heat generated in the voice coil because of its proximity to the coil at all positions of its excursion.

3. Copper shorting ring. This ring is located on the pole piece at a point midway relative to the voice coil at its normal rest position. It accomplishes two things: acting as a shorted single turn secondary to the voice coil, it minimizes the effect of voice coil inductance. This in turn allows the on-axis response of the transducers to be maintained to a higher frequency, providing better transient response.

Additionally, the copper shorting ring reduces mid-band third harmonic distortion due to flux modulation effects induced in the pole piece by the voice coil.

Performance Advantages of SVG Technology:

1. Maximum Output Capability:

Because of more effective heat sinking, the SVG transducers carry high power ratings and exhibit minimal dynamic compression when operated at full power for long periods of time.

For example, the 2227H has an input power rating of 600 watts, the same as the VGC 2226H. However, the dynamic compression at extended operation at 600 watts is 3.2 dB for the 2227H and 4 dB for the 2226H.

Additionally, the one watt, one meter midband sensitivity of the 2227H is 100 dB, compared with 97 dB for the 2226H, for a net advantage in maximum output of 3.8 dB.

Considering the 2242H, the power rating is 800 watts, as opposed to 600 watts for the 2241 H - an increase of 1.25 dB. The sensitivity of the 2242H is 99 dB, compared to 98 for the 2241 H. Dynamic compression at full power for the 2242H 3.3 dB, compared with 4.3 dB for the 2241. These values add up to a net advantage in maximum output of 3.25 dB.

We want to stress that the new SVG transducer models are not considered to be replacements for the VGC models we have compared them with. For example in applications such as motion picture theater work, a direct replacement of the 2226H with the 2227H would result in an alignment shift (response change at low frequencies) that could be significant. Additionally, the increased midband output of the 2227H would require additional equalization for motion picture applications.

2. Low Distortion Performance:

The increased output capability of the SVG transducers would be of little significance if it were accompanied by high distortion levels. Figure 2 shows a comparison of the 2226H and 2227H, both operating at one-tenth rated power. The distortion curves have been raised 20 dB for ease in reading.

The higher midband sensitivity and extended HF response of the 2227H are evident. Note that the increased damping of the 2227H produces more roll-off at low frequencies, with the 2226H actually producing about 3 dB more output below about 60 Hz. Note that the second harmonic distortion, as a proportion of the fundamental, is lower in the 2227H at the lowest frequencies.

Figure 2A.

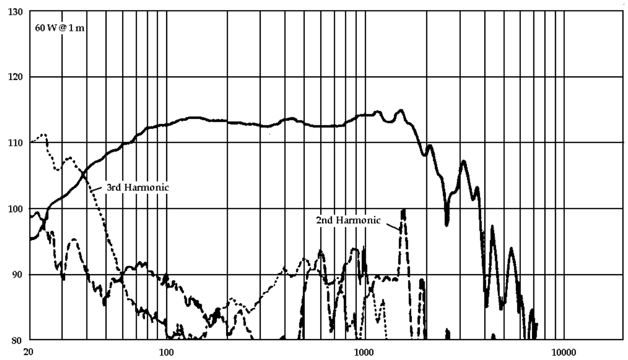
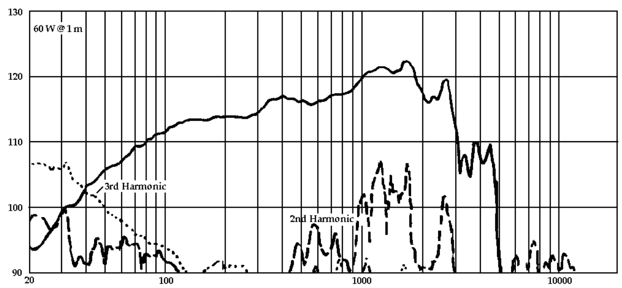


Figure 2B.



In comparing the curves on the 2241 H and 2242H shown in Figure 3, we must carefully take into account that the distortion of the 2241 H has been raised 20 dB, while the distortion of the 2242H has been raised 30 dB. This, in essence, makes the distortion of the 2242H look 10 dB greater than it really is, compared to the 2241 H. At 80 watts input, the third harmonic distortion of the 2242H is about 10 dB lower at 40 Hz than that of the 2241 H, while second harmonic distortion is about the same.

In the midband, between 100 and 500 Hz, the distortion in the 2242H is about 7 to 10 dB lower than in the 2241 H. Remember that, in these curves, we are running the 2242H at 80 watts, as compared with 60 watts for the 2241 H.

Applications:

The 2227H is intended for many applications that were traditionally filled by the E-140 and E-145 MI transducers, and the older 2220 and 2225 transducers, such as use in relatively small volume stage monitors and as drivers for low frequency horns. The relatively low value of Q_{ts} of 0.21 ensures smooth, bump-free response through the lower mid and upper bass regions in smaller enclosures and contributes to the high, extended output up to 1 kHz. We do not recommend the 2227H for use in multi-chamber or band-pass type subwoofer systems.

As a driver for bass horns, the low value of Q_{ts} contributes to a relatively low cutoff frequency in correctly designed horns and to high midband sensitivity.

The 2242H operates in similar alignments to the 2240H, but with higher input power capacity, maximum output capability, and greater linear excursion. The 2242H has excellent characteristics when used in moderate sized subwoofers, such as the JBL 4645B. In this application, a 225 liter (8 cubic foot) enclosure is tuned to 25 Hz, giving a typical over-damped response that extends smoothly from 100 Hz down to 25 Hz. Such a curve can easily be equalized for flat response over that bandwidth, particularly if multiple subwoofer modules are used. In this usage it is the functional replacement for the 2245H, as it also has approximately the same linear excursion (X_{max}) and volume displacement (V_D) capability.

Figure 3A.

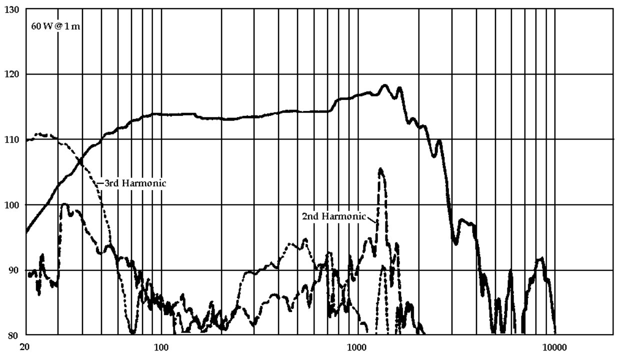
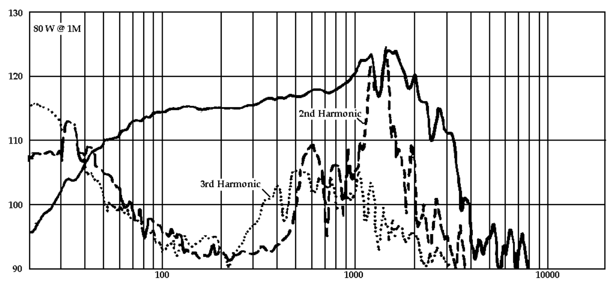
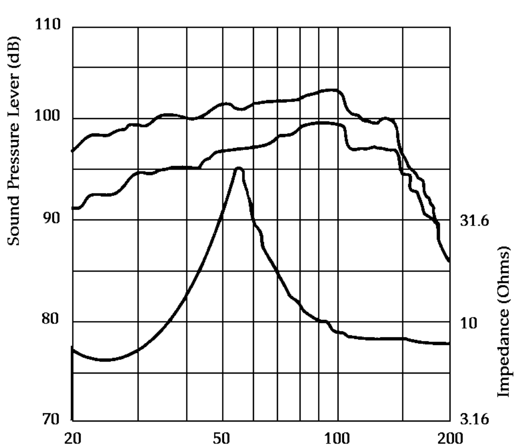


Figure 3B.



The half-space (2π) and quarter-space (1π) response of the 4645B is shown in Figure 4. While an equalizer is available that will electrically flatten these curves, such equalization may not be necessary when subwoofer modules are used in multiples. Table 1 shows tabular data of the 1/3 octave response averaged in a 5400 cubic meter (200,000 cubic foot) motion picture theater using eight such modules placed at the base of the loudspeaker/screen wall. The effect of mutual coupling with spaced units is to progressively lower the frequency at which additional modules couple, thus giving a boost at very low frequencies and flattening out the curve.

Figure 4.



The pink noise signal was low-passed 100 Hz, with no electrical boost at low frequencies. Note that, for two different averaging setups, the response from 25 to 80 Hz remains flat over a very narrow range.

Table 1. Averaged Room Response (four microphones)

Frequency:	Location 1:	Location 2:
25 Hz	79 dB	77 dB
31.5 Hz	81.5	79
40 Hz	81.5	80.5
50 Hz	81.3	80.5
63 Hz	81.7	80.5
80 Hz	78	76.5
100 Hz	74.3	74.7

Using the same one-third octave space averaging measurement setup, plots of fundamental and second harmonic distortion were recorded for sine wave inputs at a power of 80 watts (one-tenth full power rating) to each of the eight subwoofer modules. This data is presented in Table 2.

Table 2. Averaged Sine Waves and Level of Second Harmonic Distortion

Frequency:	Fundamental:	Second Harmonic Level: (relative to fundamental
25 Hz	105 dB	-42 dB
31.5 Hz	108	-35
40 Hz	103	-29
50 Hz	101	-43
63 Hz	112	-40
80 Hz	109	-45
100 Hz	104	-40

The variation in the level of the fundamental results from the fact that the test signal is a sine wave, with the expected variation in summing the levels of eight loudspeakers at four microphone locations. The important element in this data is the very low distortion level of the second harmonic component. The average measurement distance of the microphone array from the loudspeaker wall was approximately 15 meters (45 feet).

Summary:

JBL's new SVG transducers offer high output capability with low distortion. They were designed as additional drivers in JBL's line and not as replacements for existing VGC transducers.

The 2227H is intended for applications where low distortion extended range output is required. It is ideal for use in moderate size enclosures, where its high frequency capability can take it up to the 1 to 1.25 kHz range for cross over into a relatively small high frequency unit. It is also ideal as a driver for bass horn systems. We do not recommend its use in subwoofer applications.

The 2242H is ideal for theater subwoofer applications, where its low distortion and high excursion capability outperform any other transducer in the JBL line.

Specifications:

	2227H	2242H
Nominal Diameter:	380 mm (15")	460 mm (18")
Rated Impedance:	8 ohms	8 ohms
Power Capacity[1]:	600 watts	800 watts
Sensitivity, 1 W,1 m (3.3 ft)[2]:	100 dB	99 dB
Frequency Range[3]:	50 Hz - 3 kHz	25 Hz - 1.6 kHz
Power Compression[4]:		
@ -10 dB power (60 W):	0.5 dB	0.6 dB
@ -3 dB power (300 W):	1.7 dB	2 dB
@ rated power (600 W):	3.2 dB	3.3 dB
Distortion[5]:		
2nd harmonic:	< 1.0%	< 1.0%
3rd harmonic:	< 1.0%	< 1.0%
Highest Recommended Crossover:	1.6 kHz	1 kHz
Recommended Enclosure volume:	60 - 180 1 (2 - 6 ft3)	140- 340 1 (5 - 12 ft3)
Effective Piston Diameter:	334 mm (13.2 in)	397 mm (15.6 in)
Maximum Excursion Before Damage (peak-to-peak):	50mm(2 in)	50mm(2 in)
Minimum Impedance:	6.85 ohms	6.6 ohms
Voice Coil Diameter:	100 mm (4 in)	100 mm (4 in)
Voice Coil Material:	Edgewound Aluminum Ribbon	
Voice Coil Winding Depth:	17.8 mm (0.7 in)	25 mm (1 in)
Magnetic Gap Depth:	12.7 mm (0.5 in)	12.7 mm (0.5 in)
Magnetic Assembly Weight:	10.4 kg (23 lb)	10.4 kg (23 lb)
B1 Factor:	23 N/A	23.7 N/A
Effective Moving Mass:	99 g	158 g
Polarity: EIA (Positive voltage to RED terminal gives forward cone motion)		
Thiele-Small Parameters[6]:		
f_s	40 Hz	35 Hz
R_e	4.7 ohms	4.7 ohms
Q_{ts}	0.21	0.28
Q_{ms}	5	5
Q_{es}	0.22	0.29
V_{as}:	175 1 (6.2 ft3)	283 1 (10 ft^3)
S_D	0.88 m2 (137 in2)	0.124 m2 (192 in^2)
X_{max}	5 mm (0.2 in)	9mm(0.35 in)
V_D	440 cm3 (27 in3)	1114 cm3 (68 in^3)
L_e	0.55 mH	1.25 mH
η_0 (half-space):	4.9%	4%
P_e (Max)[1]:	600 W, continuous pink noise	800 W, continuous pink noise
Mounting Information: Overall Diameter:	388 mm (15.25 in)	464 mm (18.27 in)
Bolt Circle Diameter:	370 mm (14.56)	441 mm (17.38 in)
Baffle Cutout Diameter		
Front Mount:	352 mm (13.85 in)	427 mm (16/81 in)
Rear Mount:	355 mm (14 in)	428 mm (16.85 in)
Depth[7]:	152 mm(6in)	203 mm (8 in)
Volume Displaced by Driver:	7 1 (0.25 ft3)	9 1 (0.32 ft3)
Net Weight:	11.8 kg (26 lb)	13.2 kg (29 lb)
Shipping Weight:	13.2 kg (29 lb)	15 kg (33 lb)

1 AES standard (50 - 500 Hz)
2 Sensitivity is based on a 100 - 1000 Hz pink noise signal for an in put of 2.83 V @ 8 Ohms.
3 Frequency range is defined as the frequency extremes over which the response is -10 dB relative to rated sensitivity.
4 Power compression is the sensitivity loss at the specified power, measured from 50 to 500 Hz, after a 5 minute AES standard pink noise preconditioning test at the specified power.
5 Distortion is measured at -10 dB rating power, from 100 to 500 Hz.
6 Thiele-Small parameters are measured after 2 hour exercise period using a 600 W AES power test and will reflect the expected long term parameters once the driver has been installed and operated for a short period of time.
7 Clearance of at least 76 mm (3 in) must be provided behind the magnet assembly and the gap vents to allow sufficient air circulation and proper cooling to take place.

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