

Technical Notes, Volume 1, Number 24

JBL's New Maximum Output, Midrange/Low-Frequency Transducers

Introduction:

The desired performance features for dedicated midrange cone transducers are:

1. Extended power response; rising axial response
2. High electromechanical coupling (high efficiency)
3. Bandpass optimization (low mass; high resonance)
4. Low distortion at target operating levels
5. Adaptability to both direct radiator and horn use
6. High reliability

In this Tech Note we will discuss two new products, models 2012H 200 mm (10 in) and 2020H 250 mm (12 in), that meet these performance requirements in their respective size categories. These devices also have suspension elements and excursion (x_{MAX}) capabilities that allow use in certain LF applications as well.

These transducers have been designed for maximum output, with a combination of extended power response with rising on-axis response, and a combination of efficiency, sensitivity, power handling, and low dynamic power compression that make them ideal as mid and low-midrange horn drivers, as well as for low frequency use as direct radiators in stage monitors.

These transducers join the 2227H 300 mm (15 in) and 2242H 380 mm (18 in) SVG (Super Vented Gap) transducers in the Maximum Output Series (see Technical Notes Volume 1, Number 22).

Overview of Design:

Both models use a new magnetic structure with a heavy copper sleeve symmetrically positioned on the polepiece above and below the top plate. The copper sleeve is in the voice coil gap and functions as a "shorting ring," substantially reducing second and third harmonic components arising from nonlinearities in the magnetic circuit as it is modulated by the voice coil signal current.

In JBL's traditional SFG (Symmetrical Field Geometry) motor structures, an aluminum shorting ring at the base of the polepiece reduces second harmonic distortion; saturated, undercut pole tips are then used to reduce third harmonic distortion. Saturation reduces magnetic energy in the gap resulting in a loss of flux density. In the new design a larger gap is required to accommodate the copper ring, and the flux loss resulting from this is about the same as with the use of saturated pole tips. The advantage here is that both second and third harmonic are now reduced by a single design element.

The copper ring has another advantage; acting as a shorted secondary turn on a transformer (the voice coil is the primary winding), the normal rise in voice coil impedance at higher frequencies is vastly reduced as the low resistance of the shorted turn is reflected through to the primary side. This means that substantially less voltage is required to maintain flat response at the upper end of the transducer's passband.

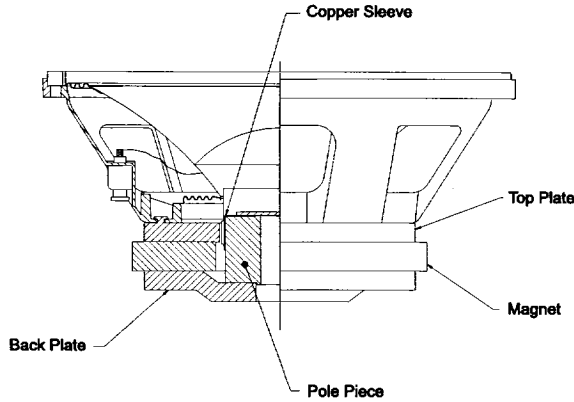
Further refinements in the moving system complete the design. Attention is given to cone and suspension materials to reduce breakup and increase overall mechanical linearity. Attention has also been given to matters of heat transfer, and dynamic power compression has been minimized.

Mechanical Details of the Design:

Figure 1 shows a section view of the 2020H magnet structure. The copper sleeve placed over the polepiece can clearly be seen, with the voice coil located just outside the sleeve. Note that the polepiece extends slightly beyond the upper surface of the top plate.

The materials comprising the cone, surround, and inner compliance (spider) have all been chosen and formed for high excursion with minimum mechanical breakup over the normal passband of the transducer.

Figure 1. Section view of 2020H magnet structure.



Performance of the Transducers:

Distortion:

The extremely low midband distortion of the 2012H is shown in Figure 2. Here, the transducer was placed in JBL's standard 290 liter (10 cu ft) sealed enclosure, in which any transducer with high electromechanical coupling will show a highly damped (rolled off) low frequency response. Input power was set at 0.1 rated power, 30 watts, attaining a midband level at one meter of 114 dB SPL. Note the extremely smooth, gradually rising response over the transducer's target operating range from 100 Hz to 2500 Hz. Over this frequency interval the values of second and third harmonic distortion do not rise above a value of 2%. Even more to the point, the distortion in the lower midrange from 100 to 600 Hz is below 1%.

Figure 3 shows data for the 2020H under similar conditions at 0.1 rated power (30 watts), attaining a level of 117 dB. Note the very low distortion over the frequency range from 80 Hz to 4 kHz. Over this frequency interval the distortion remains below 3%; over the range from 100 to 600 Hz the distortion remains below 1%.

In both designs, the level of 3rd harmonic distortion remains extremely low, normally well below 1% except at very low frequencies where the nonlinearity of the cone compliance elements becomes evident.

Figure 2. 2012H at one-tenth rated power (30 W); 2nd (dashed) and 3rd (dotted) harmonics raised 20 dB.

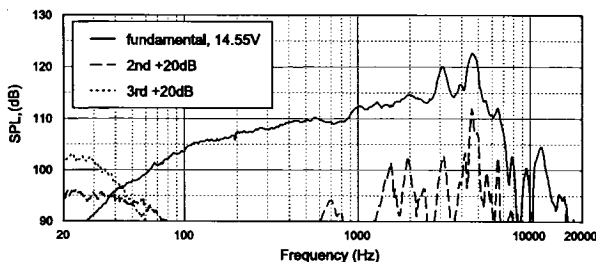
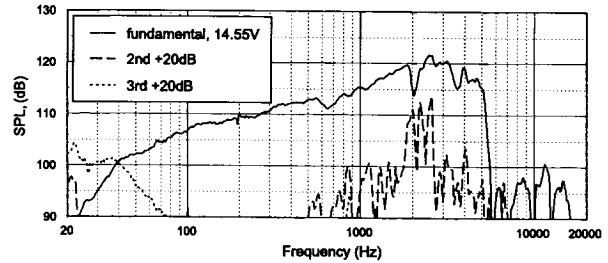


Figure 3. 2020H at one-tenth rated power (30 W); 2nd (dashed) and 3rd (dotted) harmonics raised 20 dB.

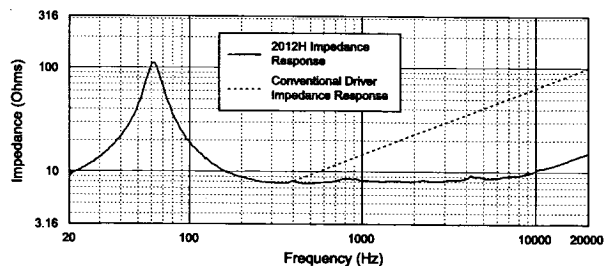


Impedance Control:

The impedance magnitude for the 2012H transducer is shown in Figure 4. The impedance is stabilized at 8 ohms over the range from about 200 Hz to 4 kHz. The dashed curve in Figure 4 shows the typical rise in impedance at mid and high frequencies in the absence of a shorting ring adjacent to the voice coil.

In the frequency range above 250 Hz, the transducer presents a uniform resistive load. This results in maximum efficiency of coupling the amplifier to the load, and presents as well an easy load for the amplifier to drive.

Figure 4. Impedance modulus for 2012H (solid curve); dashed curve shows typical rise in impedance modulus for a transducer without a copper sleeve.



Dynamic Compression:

Very few manufacturers of professional transducers routinely present performance data on power compression. Power compression results from the increase in voice coil temperature and the consequent rise in its dc resistance. When this occurs there is less power drawn from the amplifier during peak signal periods. In making power compression measurements, a 60 - 600 Hz band of pink noise with a crest factor of 6 dB is applied to the transducer at the designated power level. The transducer is then preconditioned for a period of 5 minutes at that level, and an output SPL reading is taken. This is compared with the theoretical output SPL at that power level assuming that there is no power compression present.

Power compression at high operating levels has the effect of robbing music of its essential dynamics, sounding somewhat as though a limiter/compressor has been added to the system. Power compression is normally accompanied by a shift in LF alignment that tends to make the response somewhat "boomy" and less controlled.

JBL presents this data as a guide to professional users who are concerned with performance under long-term periods of continuous usage at or near rated power:

Table 1

Model:	Compression at:	Rated power:	-3 dB:	-10 dB:
2012H	3.4 dB	2.0 dB	0.6 dB	
2020H	2.8 dB	1.7 dB	0.5 dB	

Applications:

Horn loading:

The 2012H and 2020H transducers are intended for both direct radiating and horn loaded applications. For horn loading, Keele's data shown in Figure 5, will be useful. Here, the region of flat power response on a proper horn design will be bounded by f_{LC} at low frequencies and f_{HM} at high frequencies. The various breakpoints in the graph are given as:

$$f_{LC} = (Q_{ts})f_s/2$$

$$f_{HM} = 2(f_s)/Q_{ts}$$

$$f_{HVC} = R_e/\pi L_e$$

$$f_{HC} = (2Q_{ts})f_s(V_{as}/V_{fc})$$

Where:

- Q_{ts} = total Q of the transducer
- f_s = free-air resonance of the transducer
- R_e = voice coil dc resistance (in ohms)
- L_e = voice coil inductance (in henrys)
- V_{as} = volume of air that provides a restoring force equal to that of the transducer's mechanical compliance (in liters)
- V_{fc} = volume of the horn's front air chamber (in liters)

All of the quantities needed in determining the various breakpoints can be taken from the listing of the Thiele-Small parameters for the two transducers. V_{fc} is dependent on the horn design.

Typical horn usage of the 2012H transducer in the JBL Venue Series Model 3215-9 MF section is shown in Figure 6. Note the smooth response over the interval from 300 Hz to 1 kHz and the output sensitivity of 106 dB, 1 W at 1 m.

Figure 5. Thiele-Small parameters for LF horn applications, as developed by Keele.

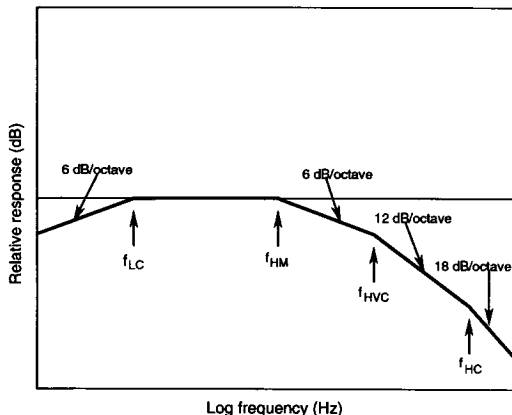
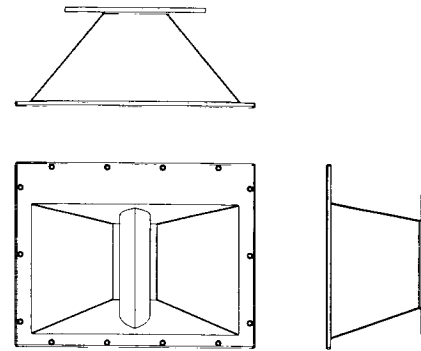
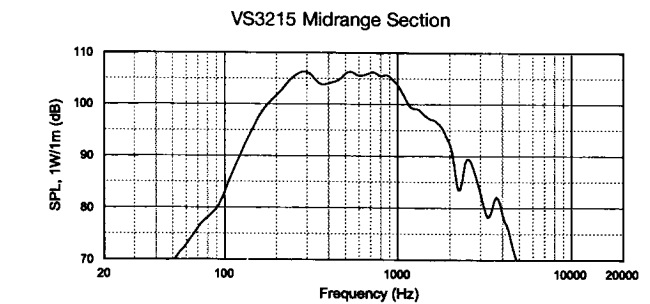


Figure 6. Example of horn loading of the 2012H in the Venue Series systems. Views of a typical mid-bass horn (a); on-axis response of the horn shown at (b) with the 2012H driver through the MF bandpass section of the dividing network. (1 W input measured at 1 m).



(a)



(b)

Direct Radiator Use; Typical Low Frequency Alignments:

Because of their relatively high resonances and very low Q_{ts} values, the 2012H and 2020H can be mounted in fairly small enclosures while maintaining smooth, peak free response. These small volume alignments normally present slightly rolled off LF response that may be easily equalized as needed. Applications may include direct radiator array elements or stage monitors. Typical LF alignments for these application are shown in Figure 7.

Specifications

	2012H:	2020H:
Nominal Diameter	250 mm (10")	300 mm (12")
Rated Impedance	8 ohms	8 ohms
Power Capacity ¹ :	300 watts	300 watts
Sensitivity, 1 W, 1 m (3.3') ² :	100 dB	103 dB
Frequency range ³ :	75 Hz to 7 kHz	50 Hz to 5.5 kHz
Power Compression ⁴ :		
@ -10 dB power (30 W)	0.6 dB	0.5 dB
@ -3 dB power (150 W)	2.0 dB	1.7 dB
@ rated power (300 W)	3.4 dB	2.8 dB
Distortion ⁵ :		
2nd harmonic:	<1.0%	<1.0%
3rd harmonic:	<1.0%	<1.0%
Highest recommended xover:	5.5 kHz	5 kHz
Recommended enclosure		
volume:	10 - 30 l (.35 - 1.05 ft ³)	30 - 90 l (1.05 - 3.2 ft ³)
Effective piston diameter:	199 mm (7.8 in)	260 mm (10.2 in.)

Maximum excursion before damage (peak-to-peak):	16 mm (0.65 in)	16 mm (0.65 in)
Minimum impedance:	7 ohms	7 ohms
Voice Coil Diameter:	76 mm (3 in)	76 mm (3 in)
Voice Coil Material:	Edgewound Aluminum Ribbon	
Voice Coil Winding Depth:	20.3 mm (0.8 in)	15.2 mm (0.6 in)
Magnetic Gap Depth:	12.6 mm (0.5 in)	12.7 mm (0.5 in)
Magnetic Assembly Weight:	7.7 kg (17 lb)	7.7 kg (17 lb)
Bl factor:	15.5 Tm	18.3 Tm
Effective Moving Mass:	30 g	44g
Polarity:	EIA (positive voltage to RED terminal gives forward displacement)	

Thiele-Small Parameters⁶:

f_s :	61 Hz	60 Hz
R_e :	4.7 ohms	4.8 ohms
Q_{ts} :	0.21	.23
Q_{ms} :	4	4.6
Q_{es} :	0.22	.24
V_{as} :	31 liters (1.1 ft ³)	65 liters (2.3 ft ³)
S_D :	.031 m ² (48 in ²)	.053 m ² (82 in ²)
x_{MAX} :	5 mm (0.2 in)	5 mm (0.2 in)
V_D :	155 cm ³ (9.4 in ³)	265 cm ³ (16.75 in ³)
L_e :	Purely resistive at 1 kHz	
$\%_0$ (half-space):	3.1%	5.32%
P_e :	300 W	300 W

continuous pink noise, continuous pink noise,
100 Hz to 1 kHz 60 Hz to 600 kHz

Mounting Information:

Overall diameter:	237 mm (9.33 in) sq. 311 mm (12.2 in)
	261mm (10.25 in) round
Bolt circle diameter:	245 mm (9.623 in) 294 mm (11.6 in)
Baffle cutout diameter:	
front mount:	229 mm (9.0 in) 280 mm (11.0 in)
rear mount:	222 mm (8.75 in) 284 mm (11.2 in)
Depth:	117 mm (4.6 in) 152 mm (6 in)
Volume displaced by driver:	2.15 liters (.076 cu ft) 4 liters (0.11 cu ft)
Net weight:	8.6 kg (19 lb) 8.6 kg (19 lb)
Shipping weight:	9.1 kg (20 lb) 9.5 kg (21 lb)

¹AES standard (60-600 for 2020H, 100-1000 for 2012H)

²Sensitivity is based on a swept 500 - 2500 Hz signal for an input of 2.83 V @ 8 ohms

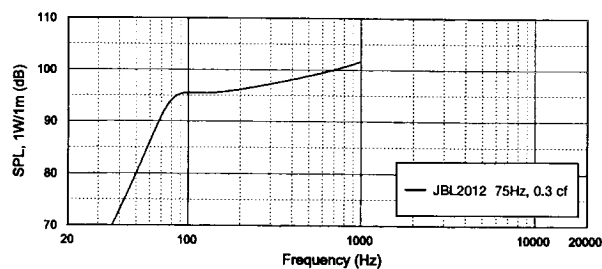
³Frequency range is defined as the frequency extremes over which the response is -10 dB relative to the rated sensitivity

⁴Power compression is the sensitivity loss at the specified power, measured from 50 to 500 Hz, after a 5 minute AES standard pink noise preconditioning period test at the specified power

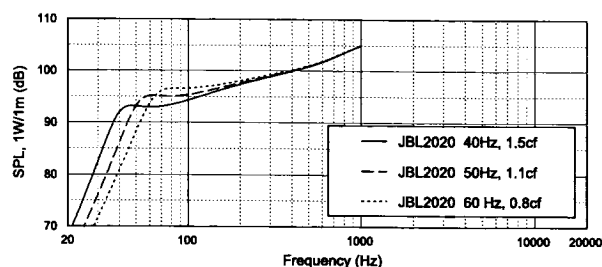
⁵Distortion is measured at -10 dB rated power, from 100 to 500 Hz

⁶Thiele-Small parameters are measured after a 2-hour exercise period using a 300 W AES power test and reflects the expected long-term parameters once the driver has been installed and operated for a short period of time.

Figure 7. Typical examples of the 2012H and 2020H transducers used in small ported enclosures. 2012H in a 0.3 cf (8.5 liter) enclosure tuned to 75 Hz (a); 2020H in a 1.5 cf (42.4 liter) enclosure tuned to 40 Hz (b); 2020H in a 1.1 cf (31 liter) enclosure tuned to 50 Hz (c); and 2020H in a 0.8 cf (22.6 liter) enclosure tuned to 60 Hz (d).



(a)



(b, c, d)

Reference:

Keele, D., "Low Frequency Horn Design Using Thiele-Small Driver Parameters," AES Preprint 1250 (presented at the 51st AES Convention, Los Angeles, May 1977).



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