



Dual Diaphragm Asymmetric Compression Drivers

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Requirements to compression drivers for pro applications

Extended frequency range

High efficiency

High power handling

Low distortion

Compact size



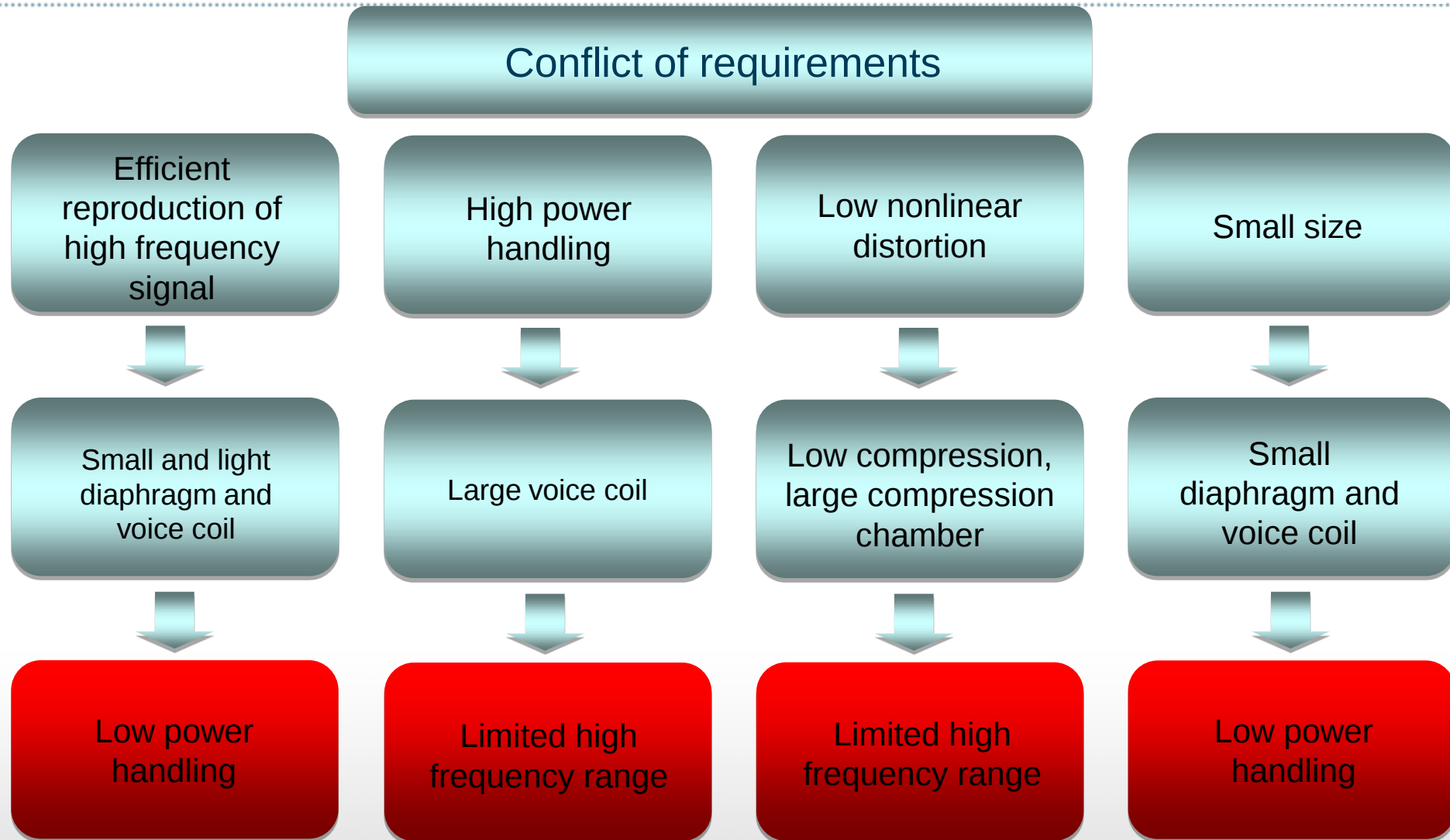
Efficient reproduction of high frequency signal

Maximum SPL at minimum input power

Reliability, high SPL

High sound quality

Multiple drivers in line arrays



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Solutions to provide
extended frequency range

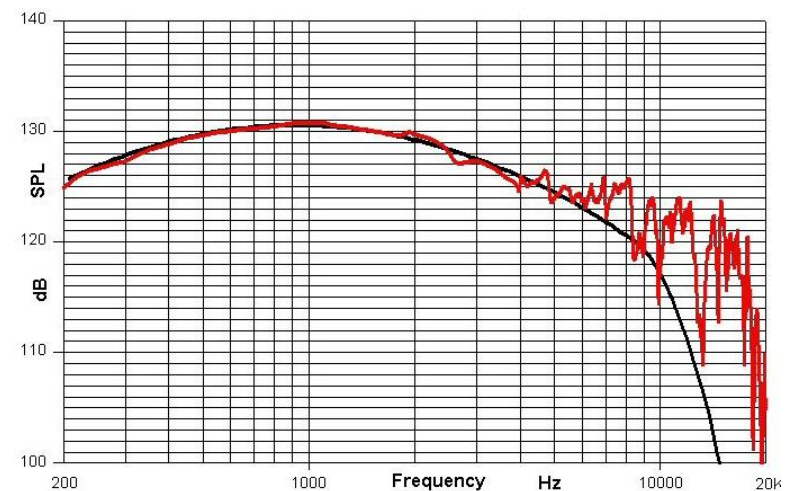
Using several smaller
drivers rather than
single large one

Limited lower
frequency
range, power
handling issues

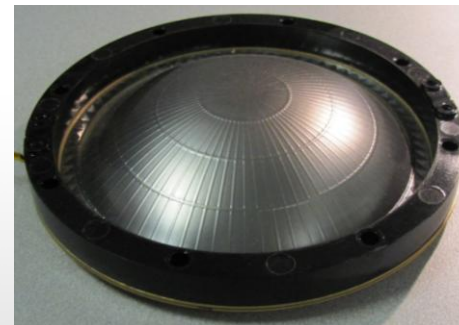


Solutions to provide
extended range frequency
range

Using high-frequency
breakups of titanium
diaphragms



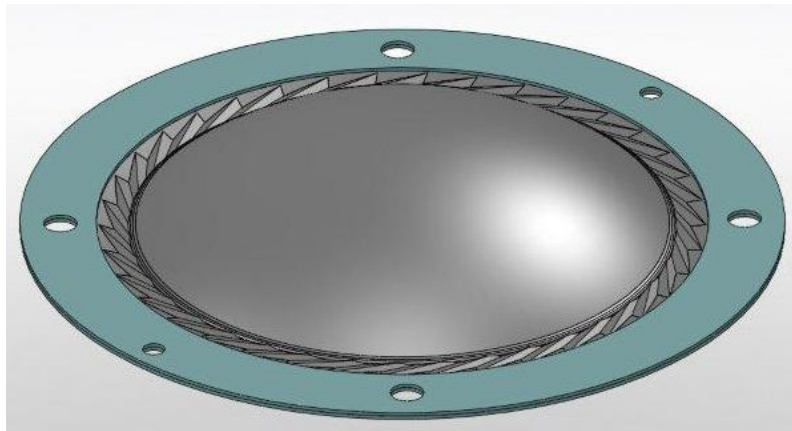
Black = Simulation
Red = Measured



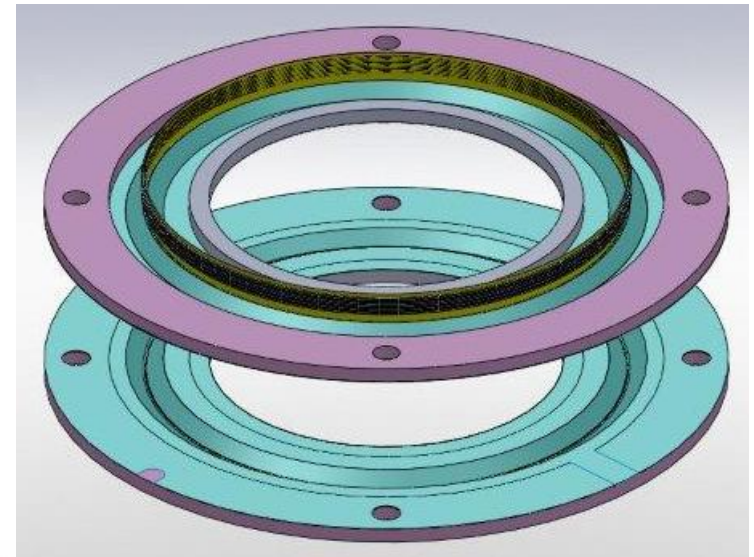
High nonlinear
distortion, severe
irregularity of the
frequency response

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Dual diaphragm solution to improve
compression driver performance



Dome diaphragm S_D



Two annular
diaphragms
 $2 \cdot S_{\text{eff}} = S_D$

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PREVIOUS CONCEPT

Dual Diaphragm compression drivers – developed initially to use in JBL new line arrays, later were used also in studio monitors

Symmetric design – based on two identical polymer annular flexural diaphragms, similar voice coils, and acoustically similar phasing plugs

High damping in annular polymer diaphragm provides low nonlinear distortion, smooth frequency response, and suppression of subharmonic distortion

Input power is split between two voice coils – lower thermal compression

Small radial dimension of annular compression chambers prevents excitation of high-frequency air resonances in the working frequency range



Dual diaphragm solution to improve compression driver performance

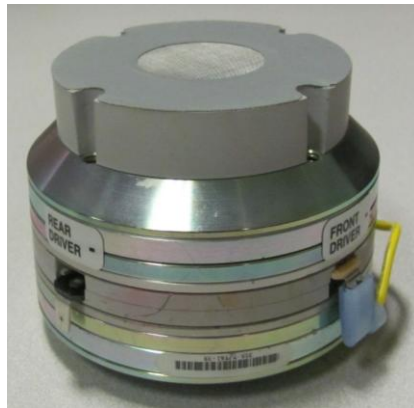
Two lighter polymer annular diaphragms instead of one metal dome diaphragm

Lower moving mass – stronger level of clean high frequency signal. Soft polymer film provides linear excursion at lower part of the frequency range

High damping in polymer diaphragm - low distortion, smooth frequency response

Input power is split between two voice coils – lower thermal compression

JBL LINE OF DUAL DIAPHRAGM COMPRESSION DRIVERS



D2430 Dual diaphragm driver
1.5" exit and 3" voice coils



D2415 Dual diaphragm driver
0.75" exit and 1.5" voice coils





JBL LINE OF DUAL DIAPHRAGM COMPRESSION DRIVERS

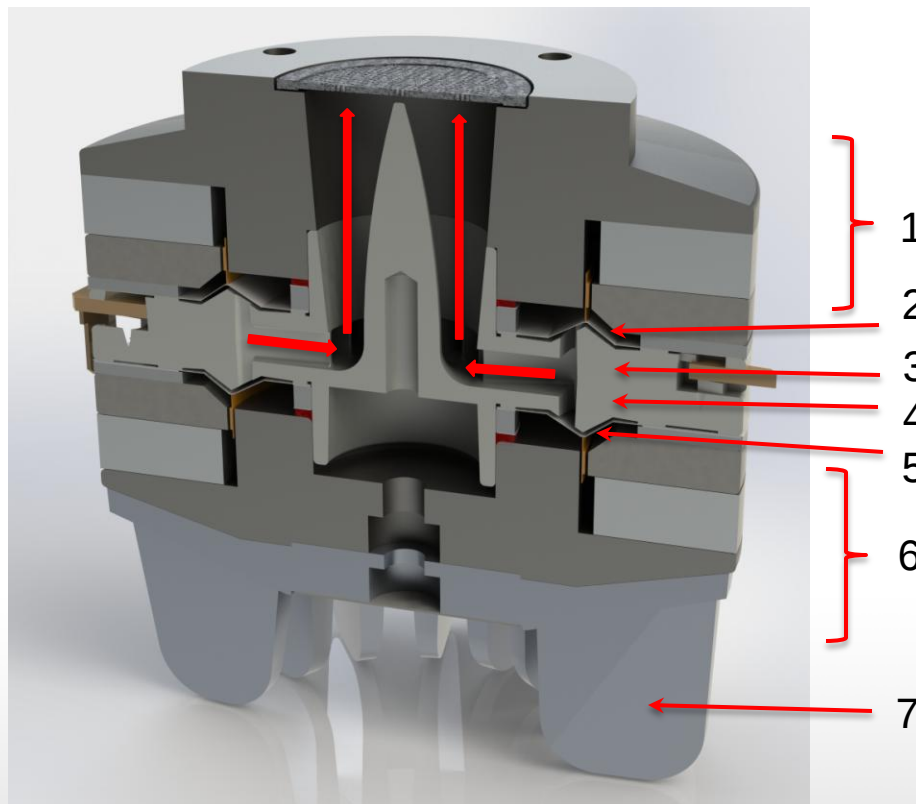


D2430 Dual diaphragm compression driver

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PREVIOUS CONCEPT

JBL D2415 dual diaphragm compression driver 1.5" voice coil, 0.75" exit



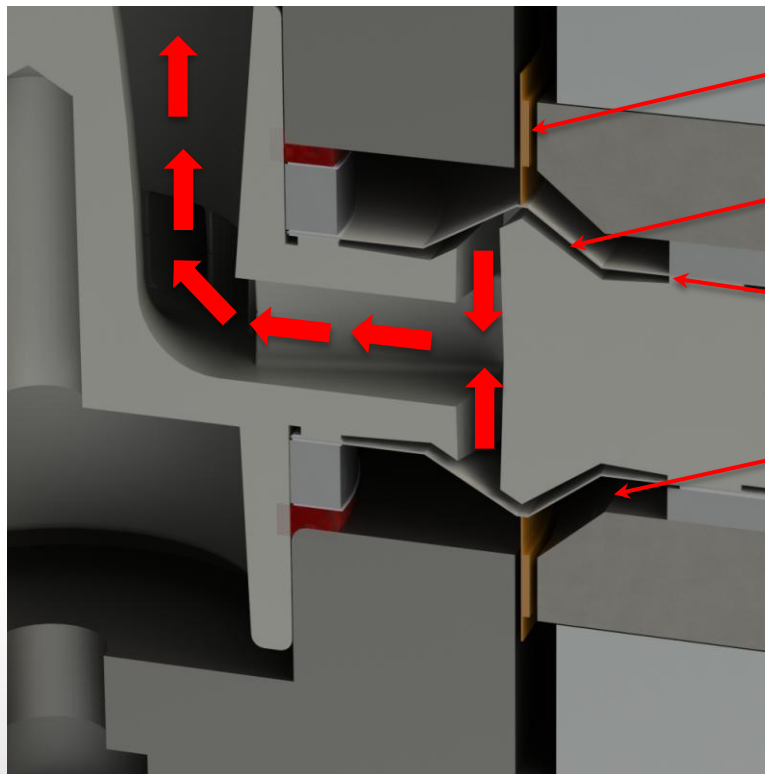
- 1 – front motor
- 2 – front diaphragm
- 3 – front phasing plug
- 4 – rear phasing plug
- 5 – rear diaphragm
- 6 – rear motor
- 7 – heatsink

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PREVIOUS CONCEPT

JBL D2415 dual diaphragm compression driver 1.5" voice coil, 0.75" exit



Voice coil and ferrofluid in the gap

Compression chamber

Diaphragm clamping

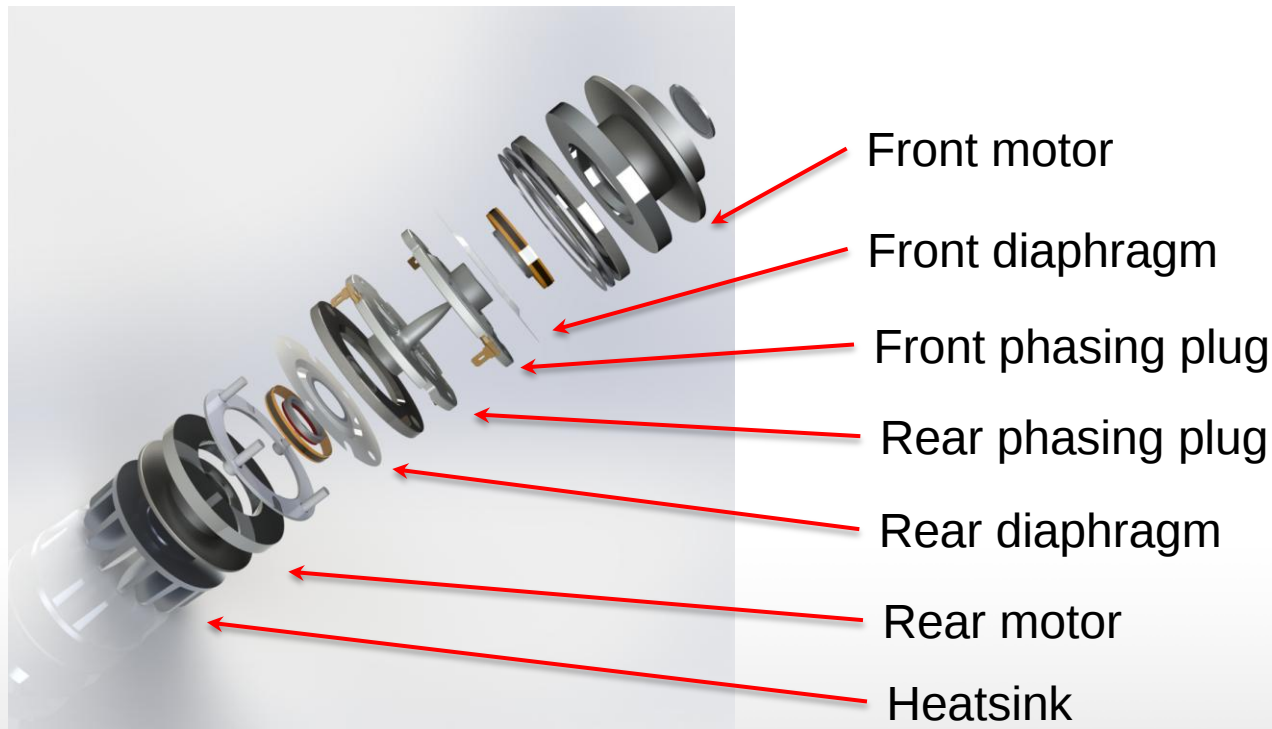
Rear volume behind diaphragm

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PREVIOUS CONCEPT

JBL D2415 dual driver 1.5" voice coil dual driver, 0.75" exit



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Applications – new JBL line arrays VTX 25 and VTX 20, M2 flagship studio monitor and Studio Monitors Series 4367 loudspeaker system



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NEW CONCEPT

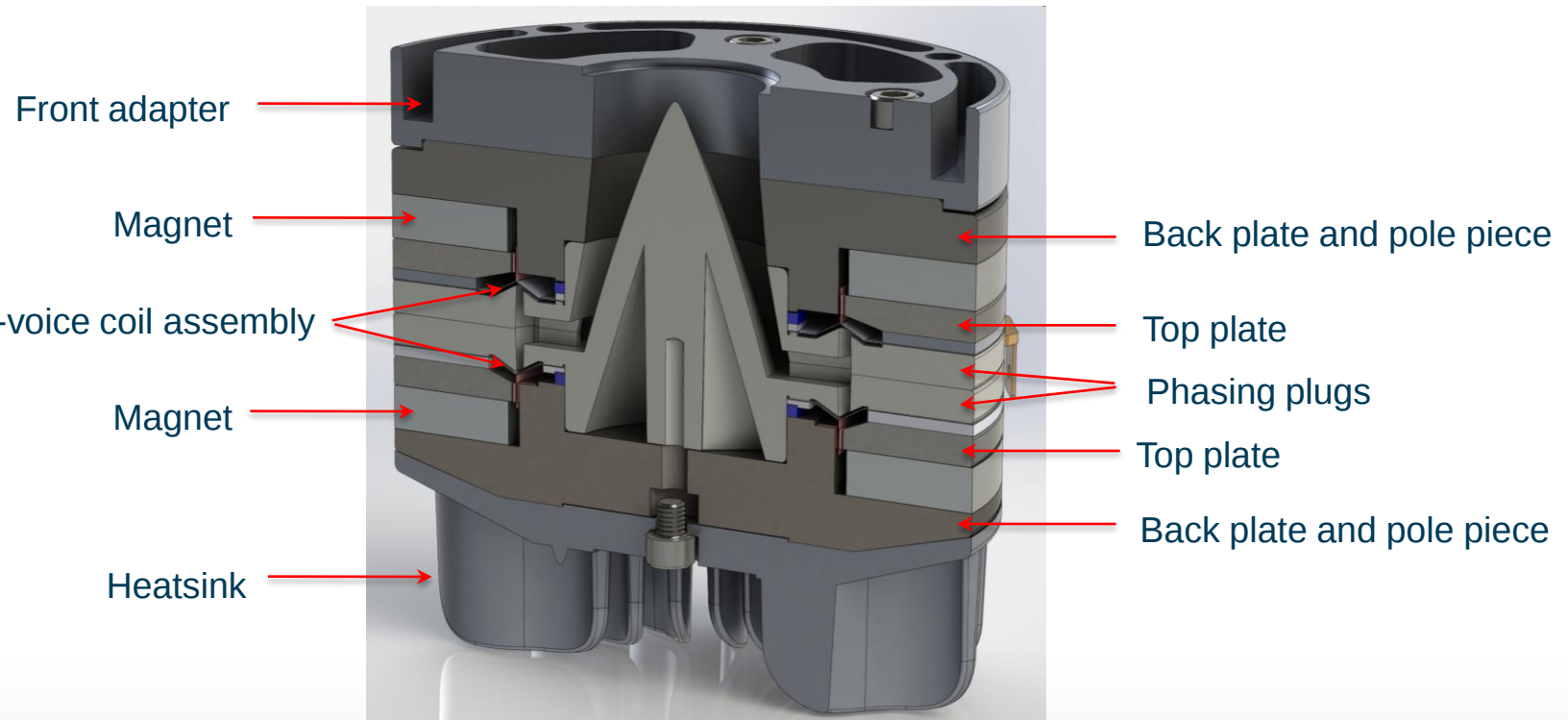
Further extension of the frequency range towards low and high frequencies

Overall configuration of the new driver is kept close to the previous design, but the diaphragms are mechanically “tuned” to different frequency ranges

Similar geometry of the annular diaphragms but they are clamped differently to provide different fundamental and “second” resonance frequencies

In-phase radiation of both “sub-drivers” at high frequencies provides extra “boost” of the high-frequency output

NEW CONCEPT

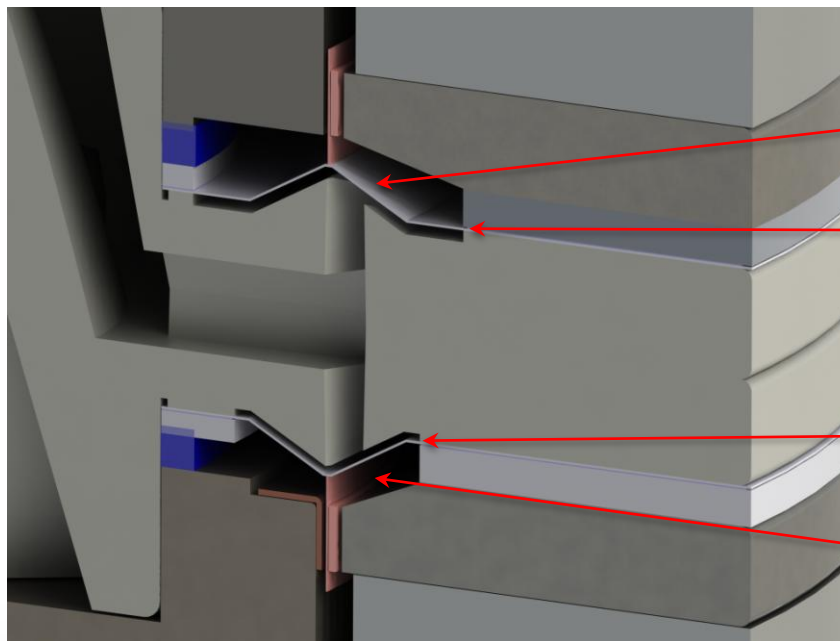


JBL DA2420 dual diaphragm asymmetric compression driver
2" voice coil, 1" exit

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NEW CONCEPT



Midrange diaphragm assembly

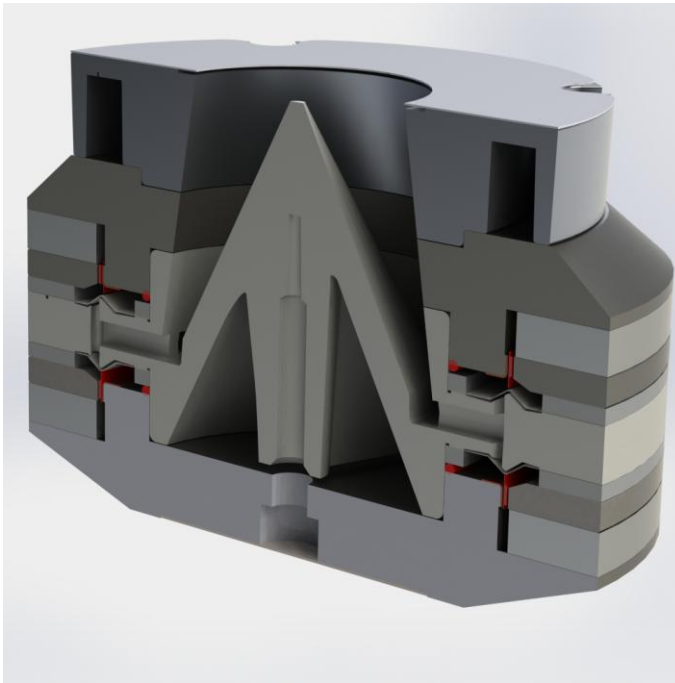
Midrange diaphragm clamping

High-frequency diaphragm clamping

High-frequency diaphragm assembly

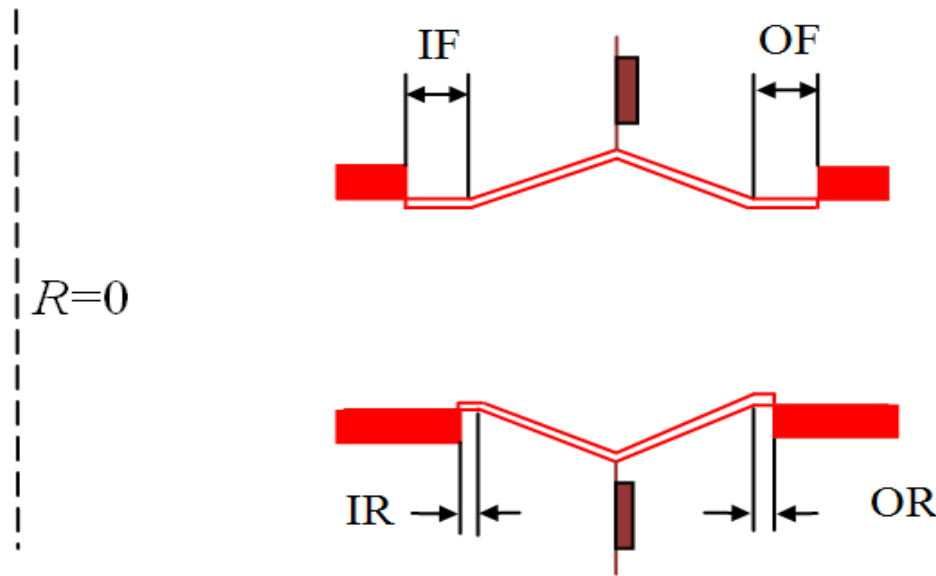


NEW CONCEPT



DA2430 dual diaphragm compression driver. 3" voice coil, 1.5" exit

NEW CONCEPT



IF and OF – inside and outside clamping dimensions of the front (MF) diaphragm

IR and OR – inside and outside clamping dimensions of the rear (HF) diaphragm



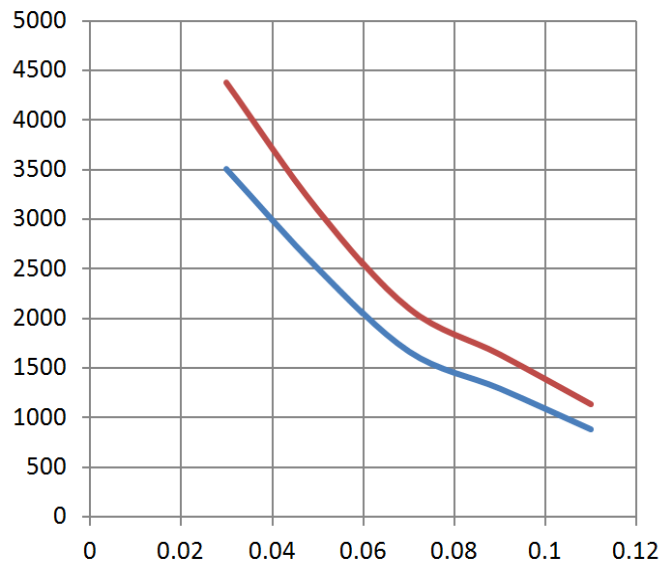
NEW CONCEPT

Table 1

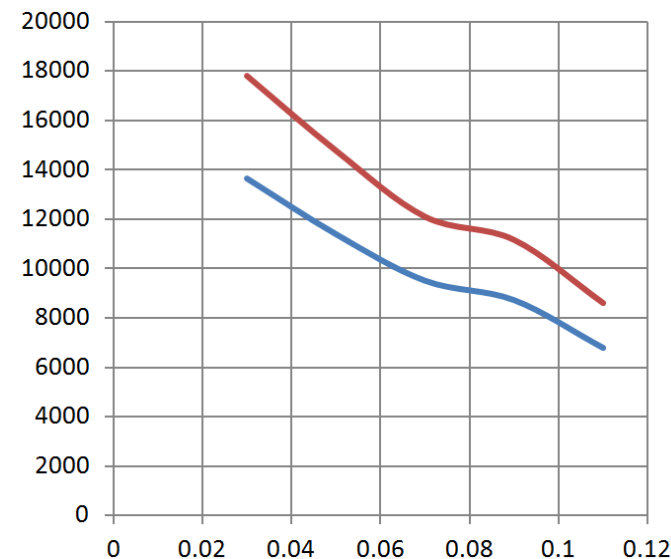
Clamp size, inch	Fundamental resonance, Hz		Second resonance, Hz	
	75 microns	100 microns	75 microns	100 microns
0.030"	3503	4380	13645	17820
0.050"	2507	3100	11390	14780
0.070"	1667	2104	9505	12095
0.090"	1294	1640	8718	11154
0.110"	880	1140	6790	8586

Dependence of fundamental and “second” resonance frequencies on clamping dimensions and diaphragms’ thickness. ANSYS FEA simulations

NEW CONCEPT



Fundamental resonance frequency

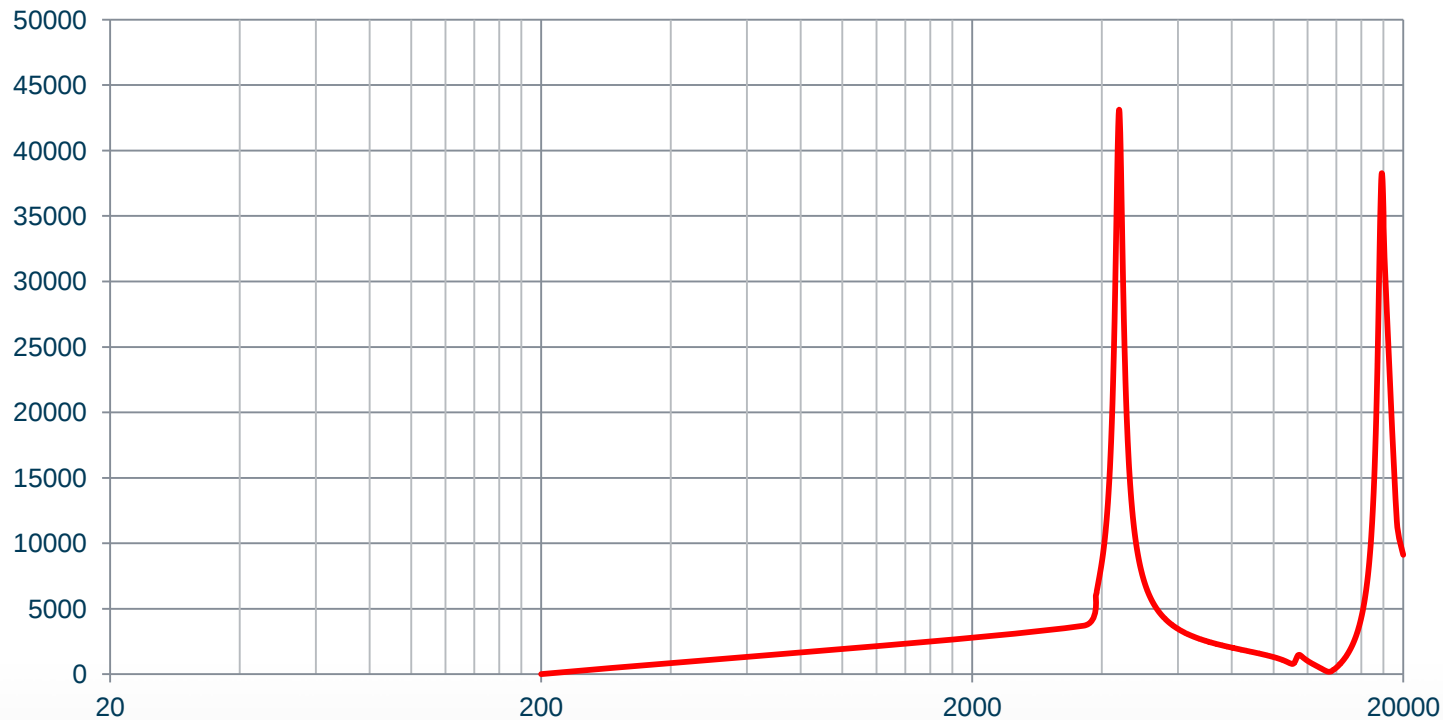


"Second" resonance frequency

Dependence of fundamental and "second" resonance frequencies on clamping dimensions and material thickness. Blue – 75 microns, red – 100 microns. FEA ANSYS simulations.



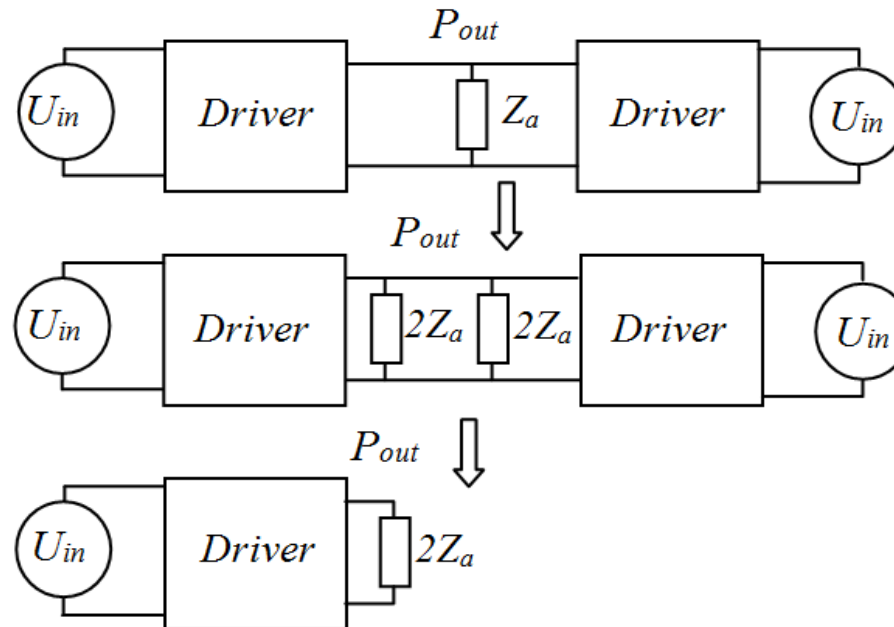
NEW CONCEPT



Overall axial acceleration of 100 micron-thick annular flexural polymer diaphragm with clamping dimension 0.030". FEA ANSYS simulation.

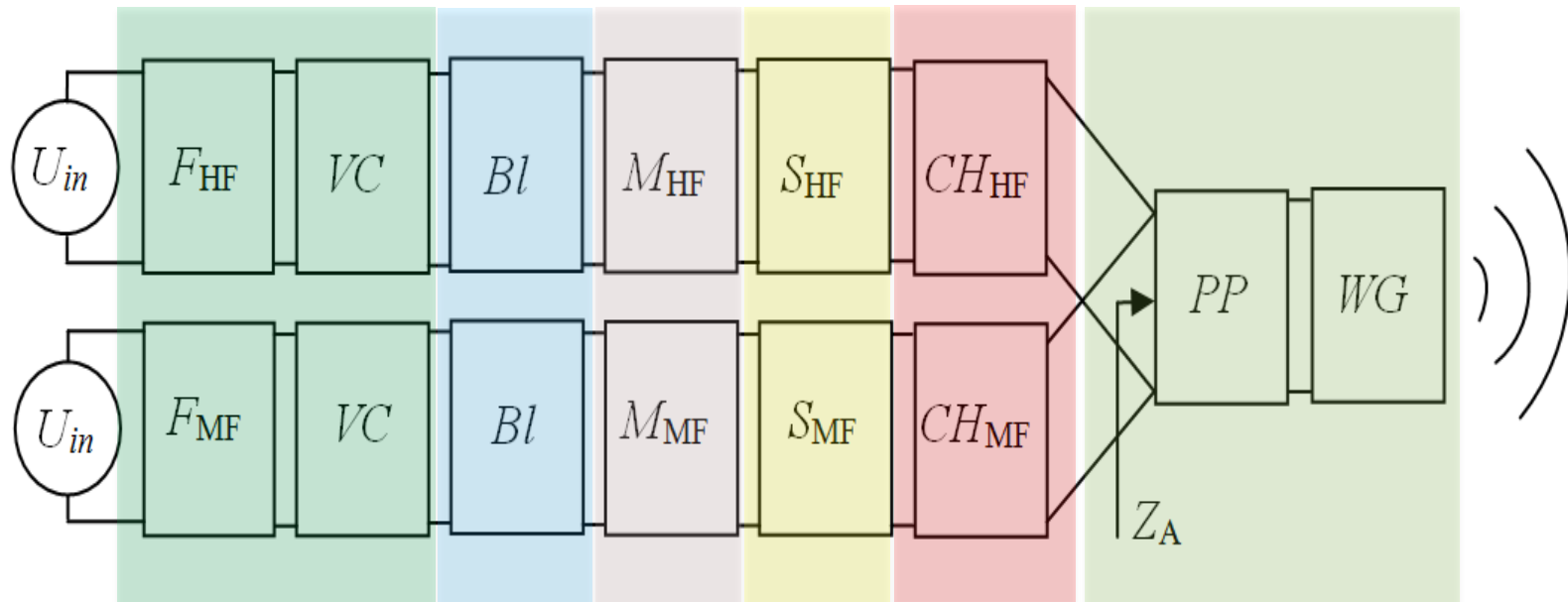
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PREVIOUS CONCEPT



Transformation of the matrix model of symmetric dual driver to the single driver dual model

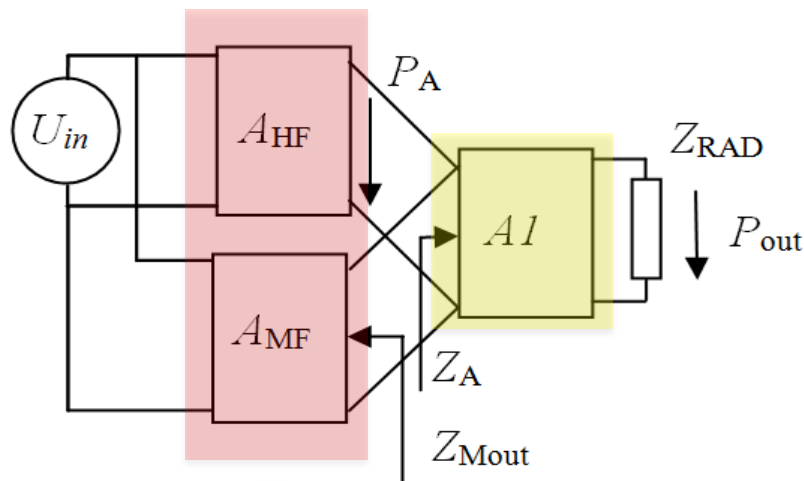
NEW CONCEPT



Matrix presentation of dual asymmetric compression driver

(1)

NEW CONCEPT



$$A_{HF} \Rightarrow Y_{HF}$$

$$A_{MF} \Rightarrow Y_{MF}$$

$$Y_{HF} + Y_{MF} \Rightarrow Y_{\Sigma}$$

$$Y_{\Sigma} \Rightarrow A_{\Sigma}$$

$$\Downarrow$$

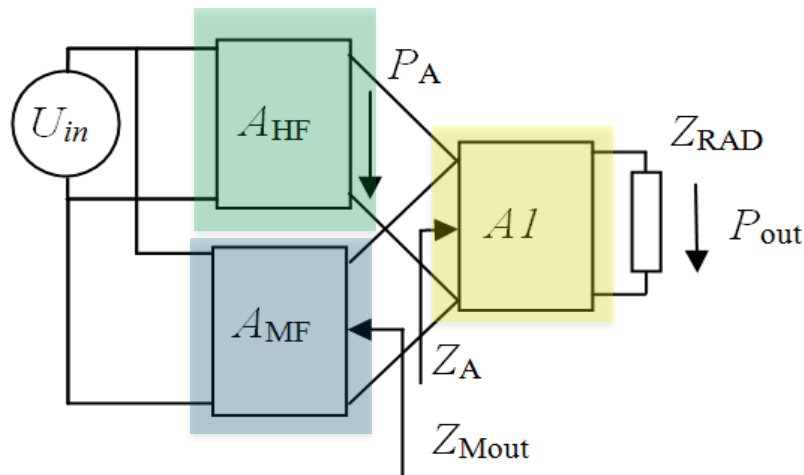
$$A_{\Sigma}$$

$$P_A = \frac{U_{in}}{A_{\Sigma 11} A_{11} + A_{\Sigma 12} A_{12} + (A_{\Sigma 11} A_{12} + A_{\Sigma 12} A_{22}) / Z_{RAD}}$$

Modeling of the asymmetric dual driver sound pressure response

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NEW CONCEPT



$$Z_{Mout} = \frac{\text{inv}[A_{MF12}]}{\text{inv}[A_{MF22}]}$$

$$Z_{MA} = \frac{Z_{Mout} Z_A}{Z_{Mout} + Z_A}$$

$$P_A = \frac{U_{in}}{A_{HF11} + A_{HF12} / Z_{MA}}$$

$$P_{out} = \frac{P_A}{A1_{11} + A1_{12} / Z_{RAD}}$$

Modeling of HF driver's sound pressure response



NEW CONCEPT



DA2420 Front View



DA2420 Rear View



DA2420 loaded by
Holland-Newell horn



Heatsink Prior Art

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NEW CONCEPT

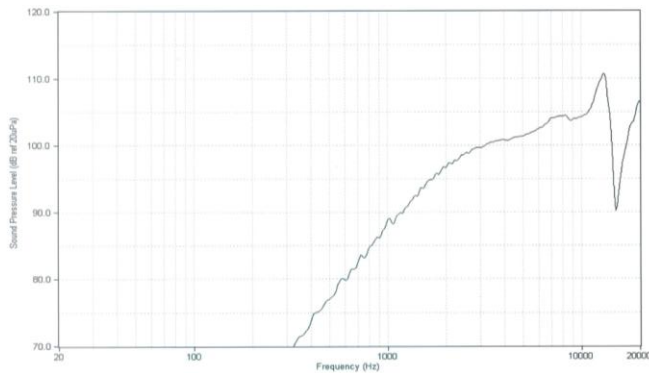


HF Open Diaphragm scanning by Klippel scanner

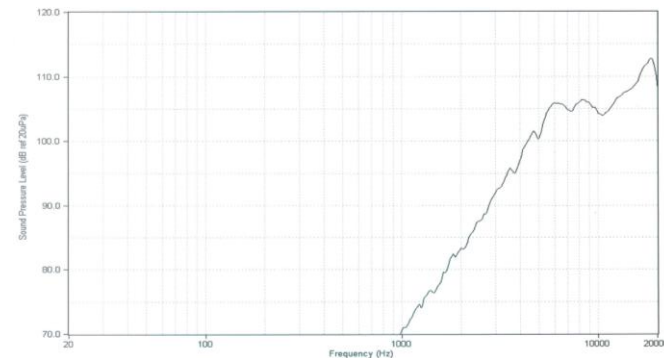


MF Open Diaphragm. 2Pi anechoic chamber measurement

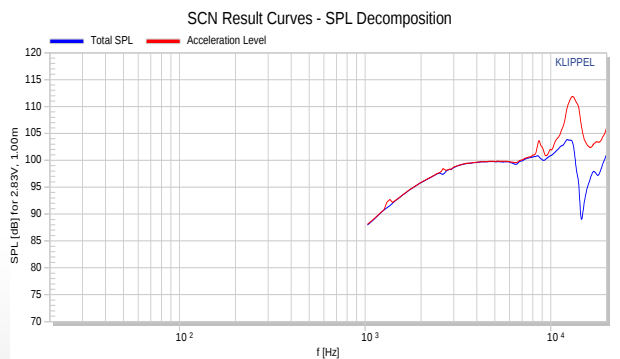
NEW CONCEPT



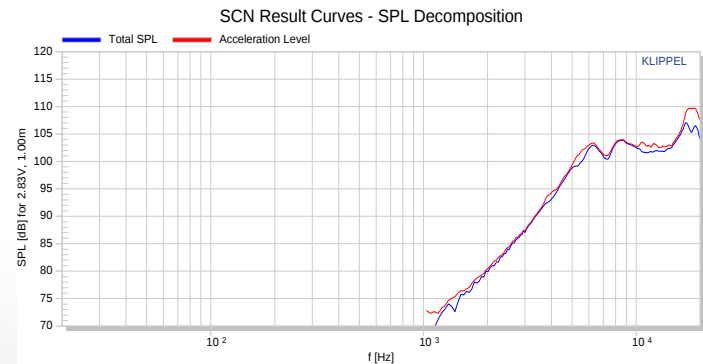
MF Open Diaphragm. Anechoic 2Pi chamber SPL response



HF Open Diaphragm. Anechoic 2Pi chamber acceleration and SPL response



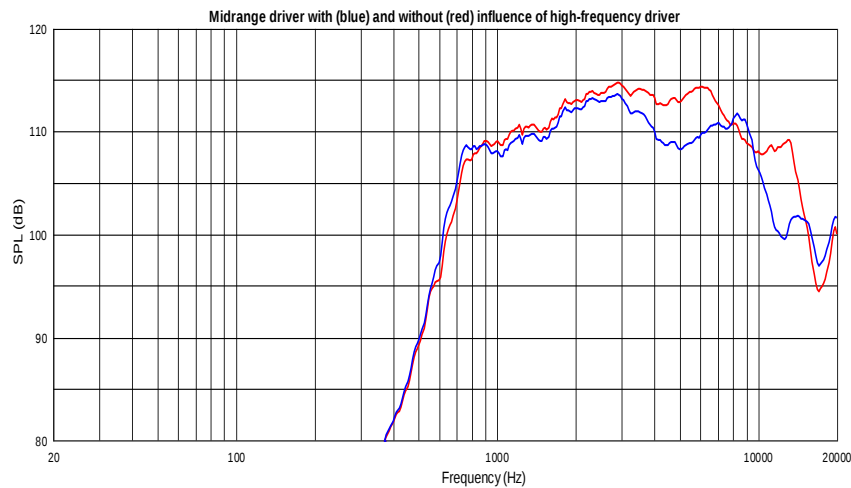
MF Open Diaphragm. Klippel Scanner acceleration and SPL response



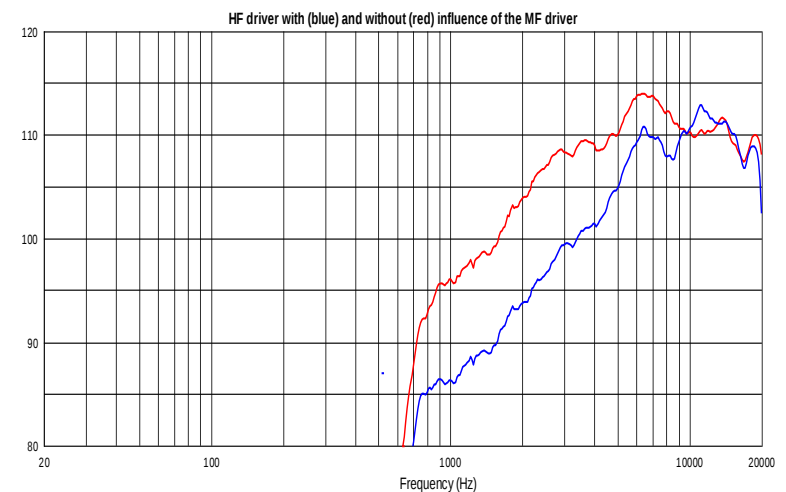
HF Open Diaphragm. Klippel Scanner SPL response simulation

NEW CONCEPT

Mutual influence of HF and MF drivers



MF driver, SPL response. Red – single,
blue – coupled with HF driver.

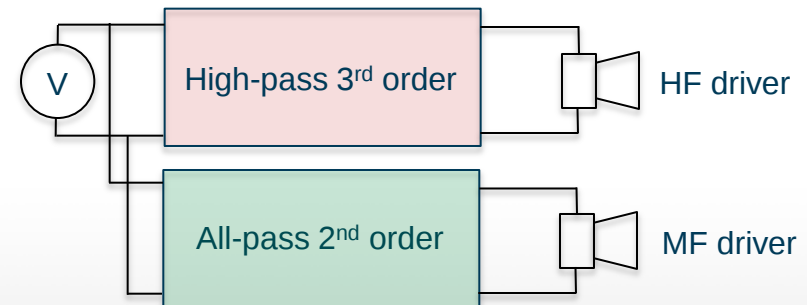
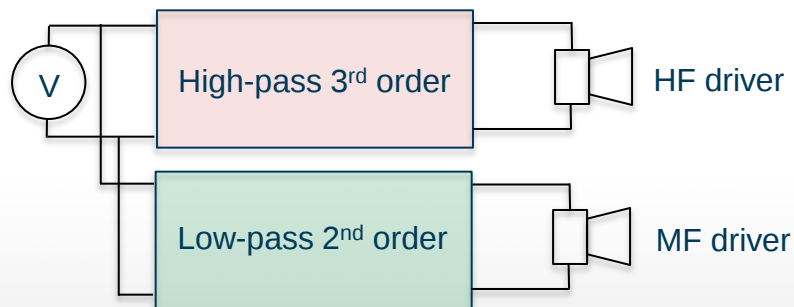
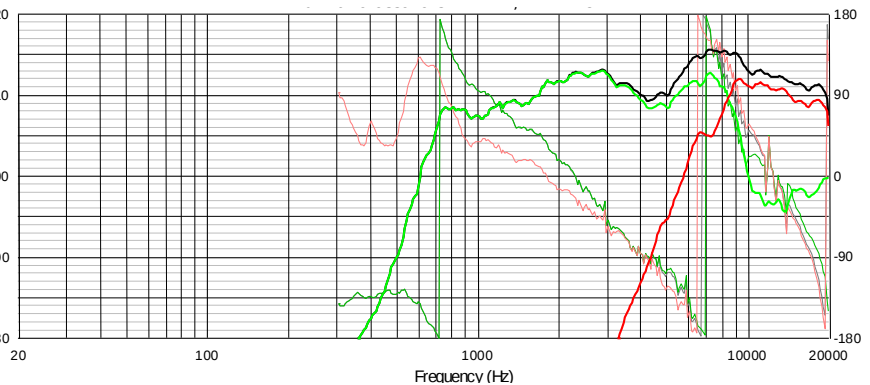
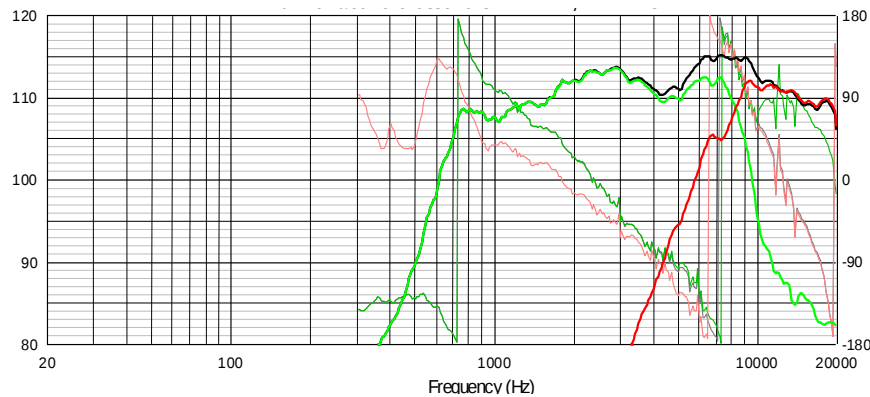


HF driver, SPL response. Red – single,
blue – coupled with MF driver.

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NEW CONCEPT

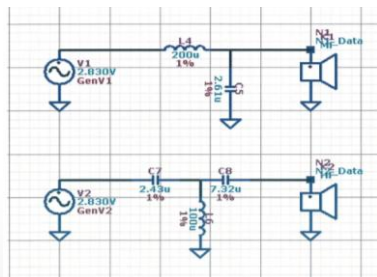
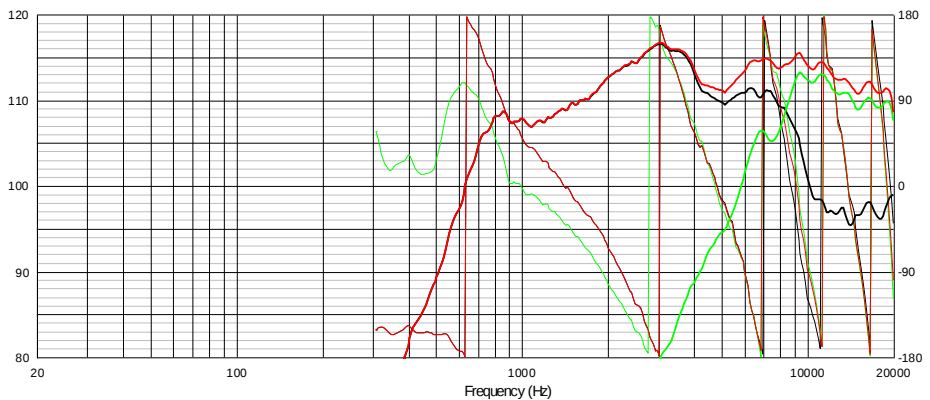
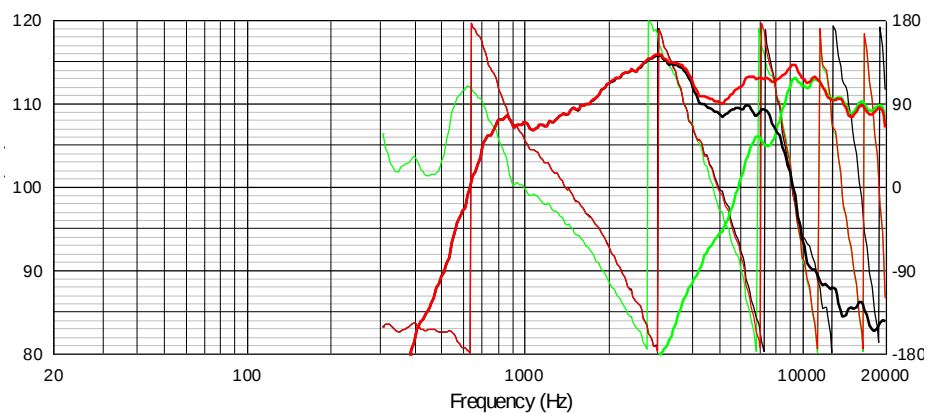
Active crossovers



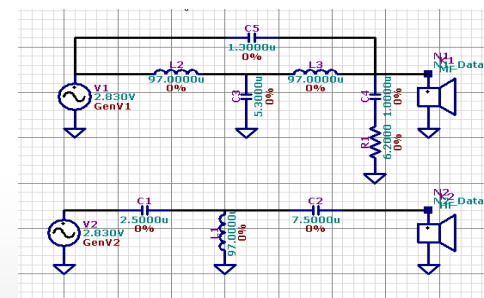
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NEW CONCEPT

Passive crossovers



MF driver: Low-pass 2nd order
HF driver – High-pass 3rd order



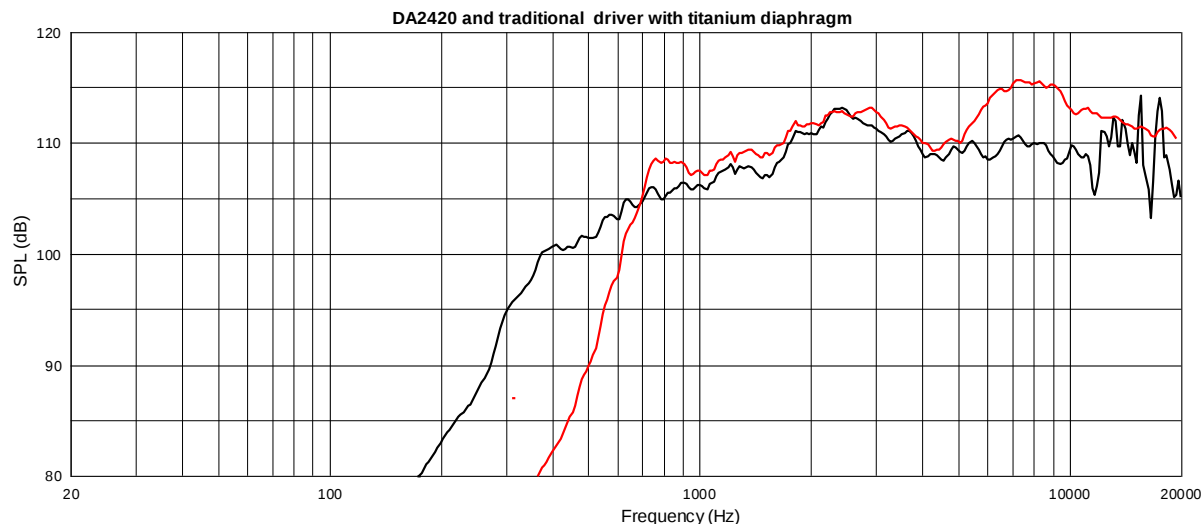
MF driver: All-pass 2nd order
HF driver – High-pass 3rd order

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NEW CONCEPT

DA2420 and traditional driver with 3" titanium dome diaphragm

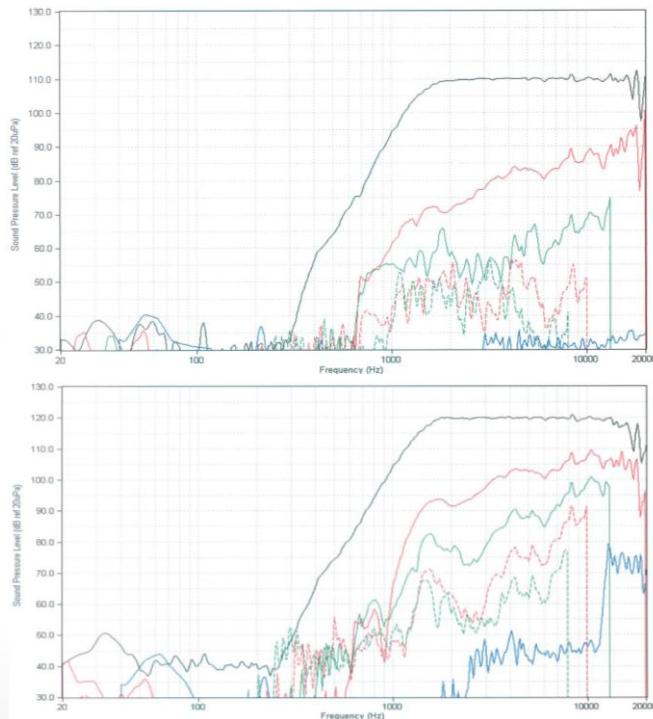


Red – DA2420. Blue – traditional driver with titanium dome diaphragm loaded by
Holland-Newell axisymmetric horn. 2Pi anechoic chamber responses

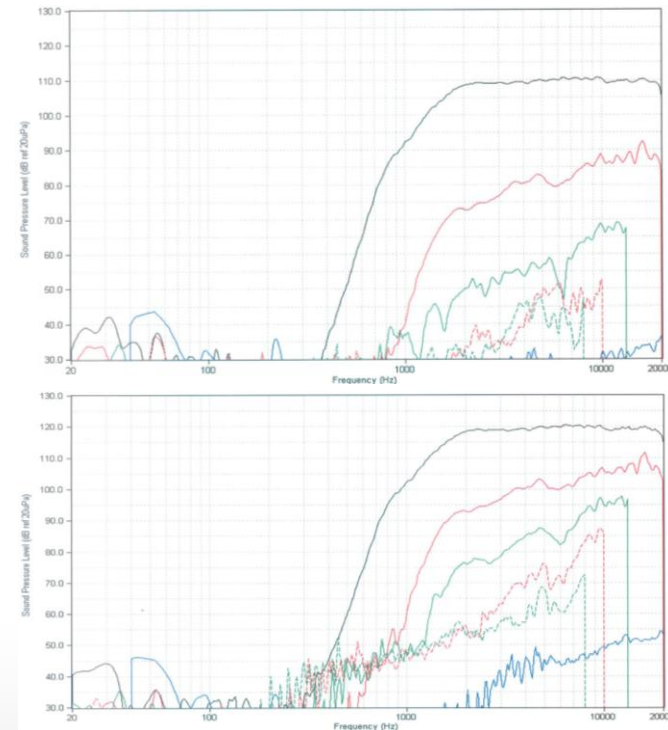
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NEW CONCEPT

DA2420 and traditional driver with 3" titanium dome diaphragm



Traditional driver with 3" titanium dome diaphragm



New driver, 2" voice coils

Harmonic distortion comparison for 110 dB SPL and 120 dB SPL

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CONCLUSION

New configuration of dual diaphragm compression driver has been developed

The new design is based on two annular flexural diaphragms mechanically “tuned” to different frequency ranges

SPL outputs of MF and HF drivers overlap over HF frequency range to increase high frequency SPL

New driver uses advantages of polymer annular flexural diaphragms – smooth frequency response and low nonlinear distortion.

The new technology is currently implemented in dual asymmetric compression driver – DA2420 which will be used in JBL new line array



END