Dual Diaphragm Asymmetric Compression Drivers

Alex Voishvillo

AES Fellow

JBL PROFESSIONAL

139h AES Convention, New York, October 30th 2015

Dual Diaphragm Asymmetric Compression Drivers

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

Dual Diaphragm Asymmetric Compression Drivers

Conflict of requirements

Efficient reproduction of high frequency signal	High power handling	Low nonlinear distortion	Small size
Small and light diaphragm and voice coil	Large voice coil	Low compression, large compression chamber	Small diaphragm and voice coil
Low power handling	Limited high frequency range	Limited high frequency range	Low power handling

Dual Diaphragm Asymmetric Compression Drivers

Solutions to provide extended frequency range

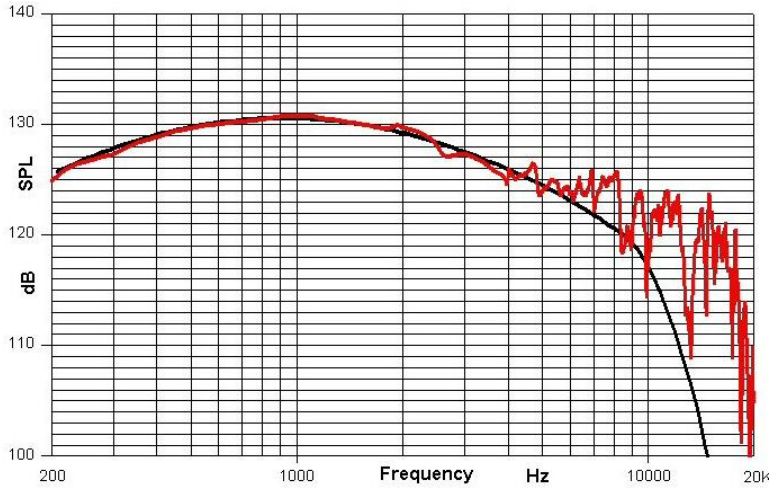
Using several smaller drivers rather than single large one

Limited lower frequency range, power handling issues

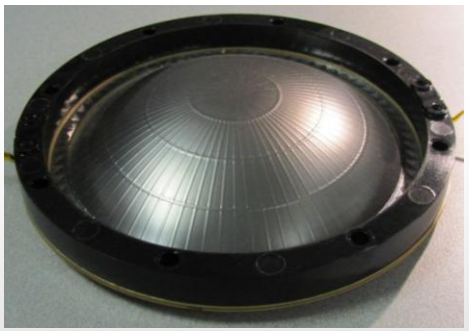
Dual Diaphragm Asymmetric Compression Drivers

Solutions to provide extended range frequency range

Using high-frequency breakups of titanium diaphragms

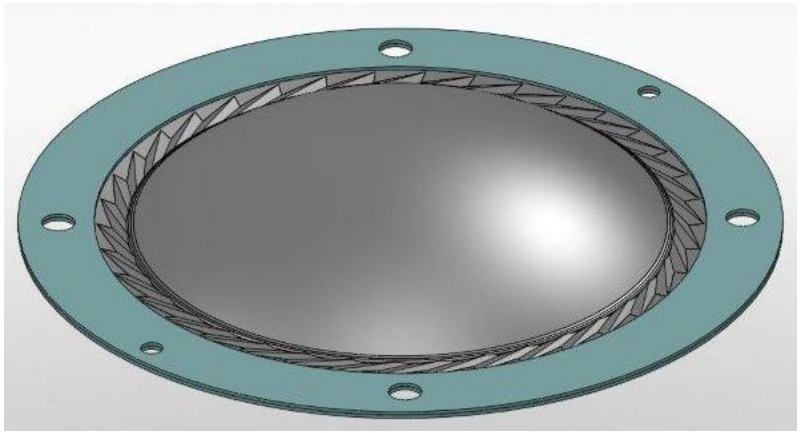


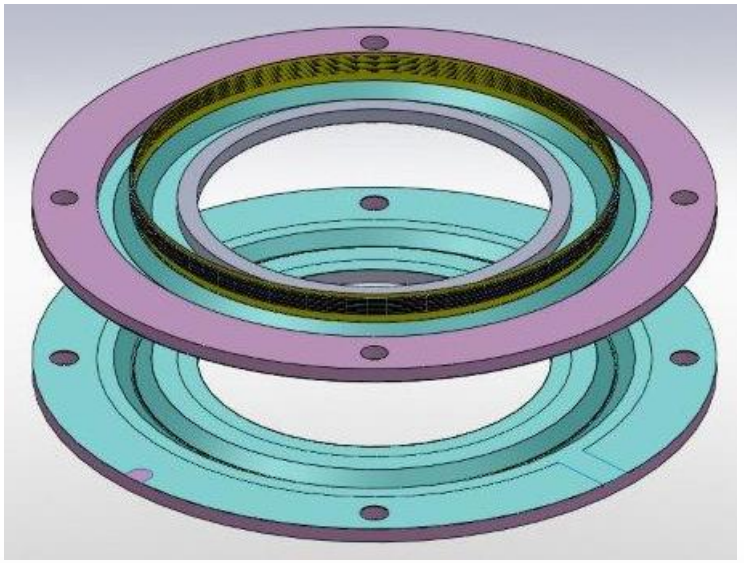
High nonlinear distortion, severe irregularity of the frequency response



Dual Diaphragm Asymmetric Compression Drivers

Dual diaphragm solution to improve compression driver performance





Dome diaphragm S_D

Two annular diaphragms
$2*S_{eff} = S_D$

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 Asymmetric Compression Drivers

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

Dual Diaphragm Asymmetric Compression Drivers

JBL LINE OF DUAL DIAPHRAGM COMPRESSION DRIVERS

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

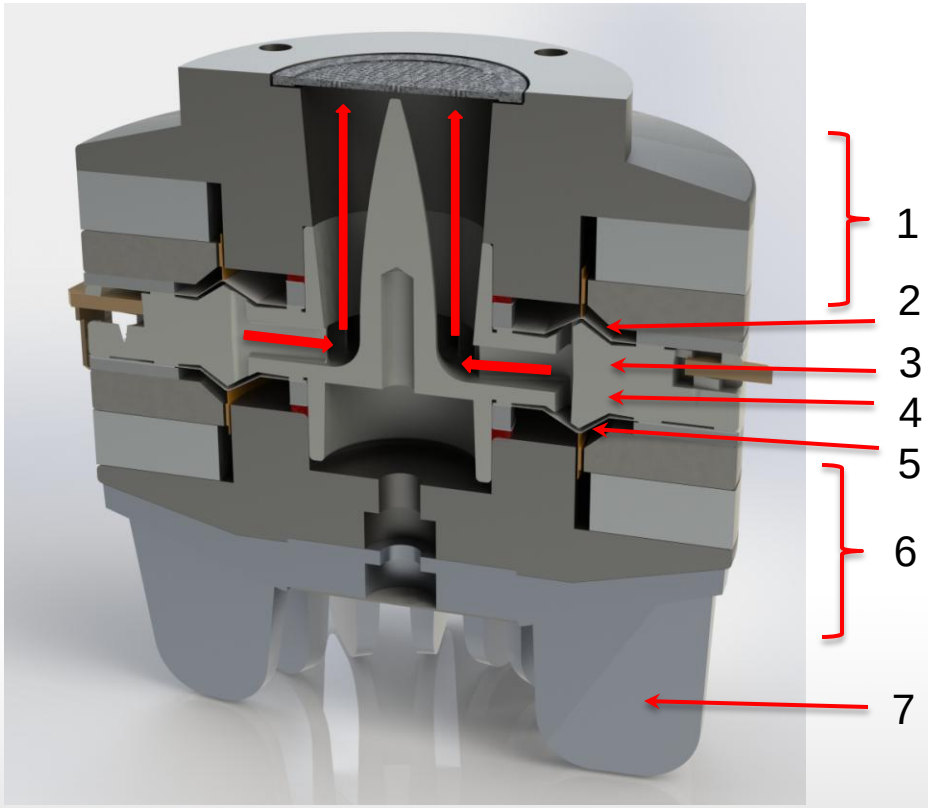
D2415 Dual diaphragm driver
0.75” exit and 1.5” voice coils

JBL LINE OF DUAL DIAPHRAGM COMPRESSION DRIVERS

D2430 Dual diaphragm compression driver

PREVIOS 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

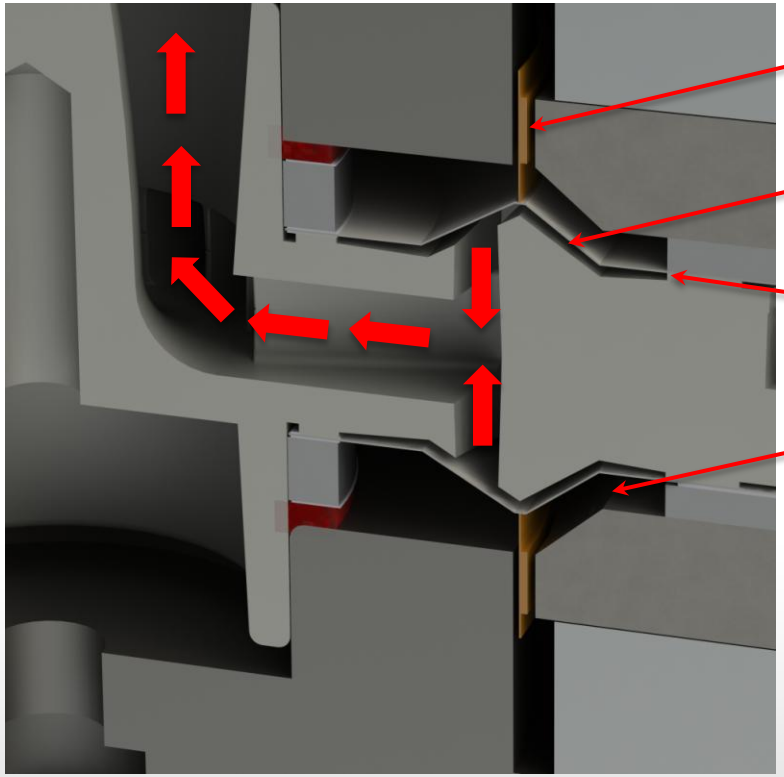
5 – rear diaphragm

6 – rear motor

7 – heatsink

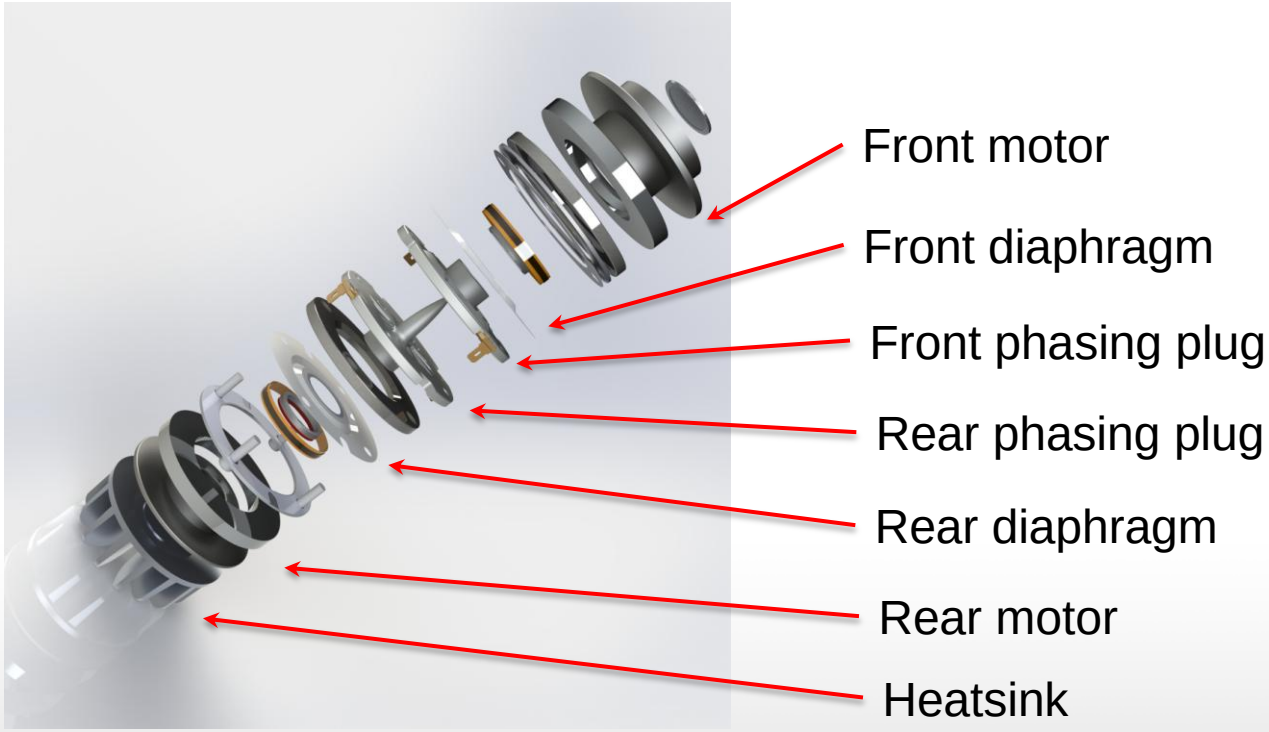
PREVIOS CONCEPT

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



PREVIOS CONCEPT

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



Dual Diaphragm Asymmetric Compression Drivers

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

NEW CONCEPT

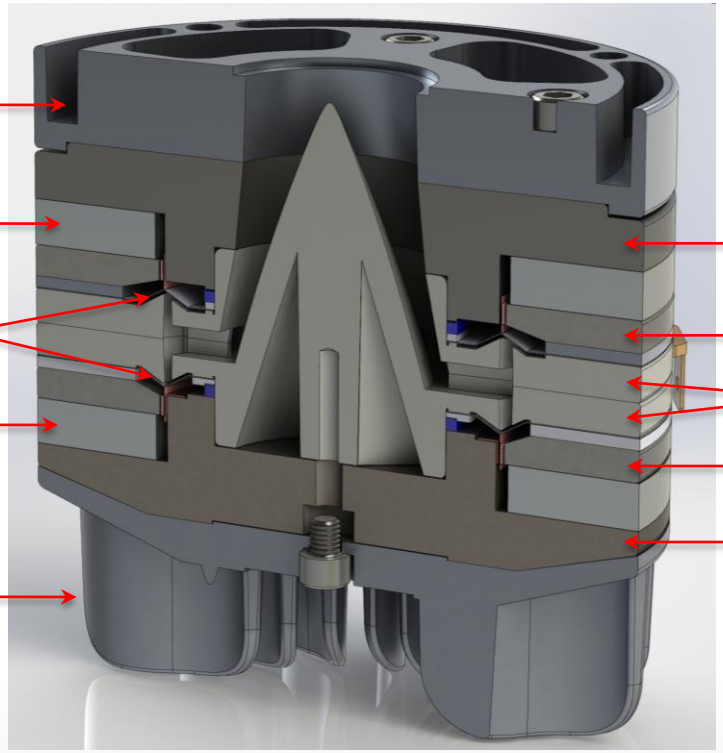
Further extension of the frequency range towards low and high frequencies

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

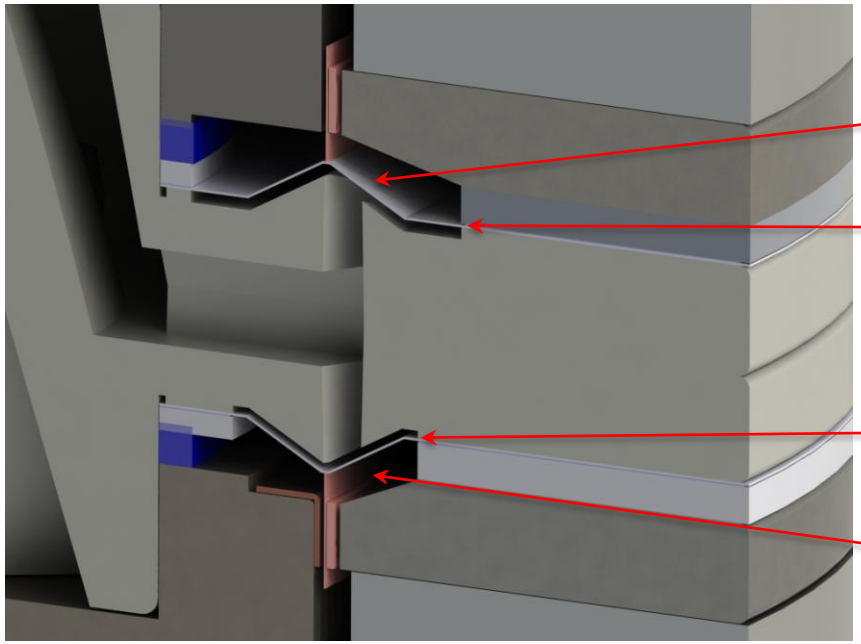
In-phase radiation of both “sub-drivers” at high frequencies provides extra “boost” of the high-frequency output

NEW CONCEPT



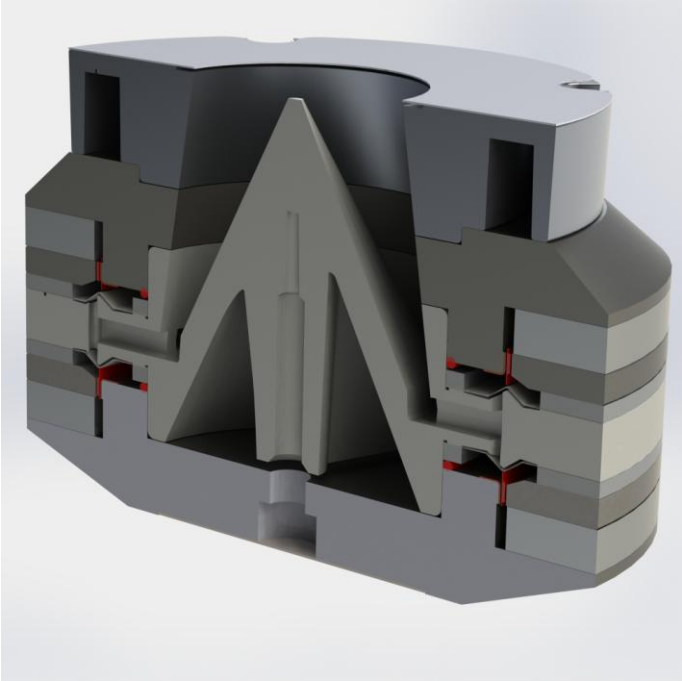
JBL DA2420 dual diaphragm asymmetric compression driver
2” voice coil, 1” exit

NEW CONCEPT



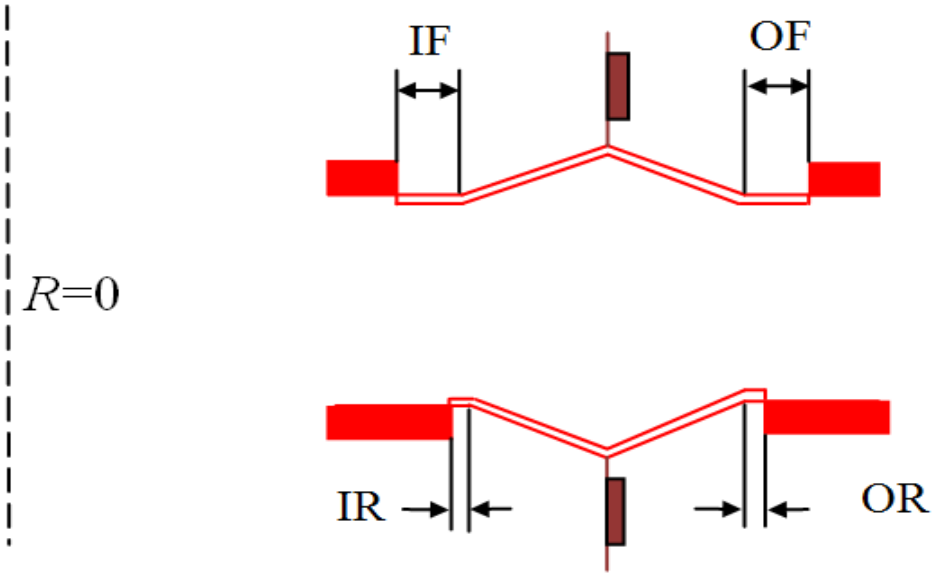
Dual Diaphragm Asymmetric Compression Drivers

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

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

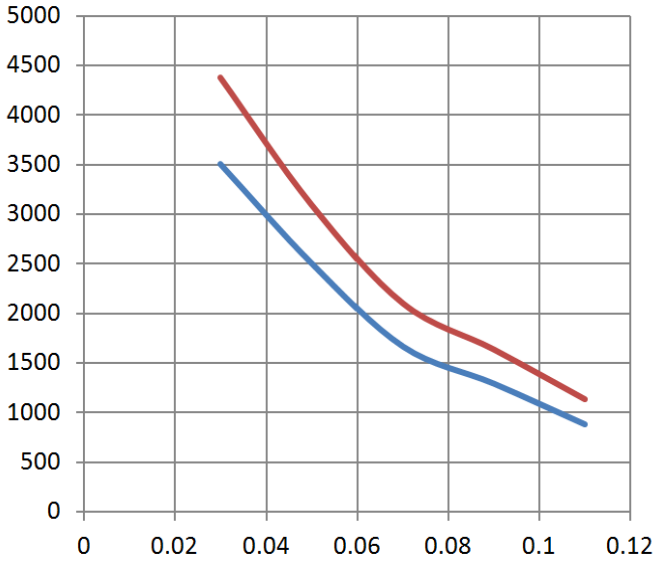
Table 1

	Fundamental resonance, Hz		Second resonance, Hz	
Clamp size, inch	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

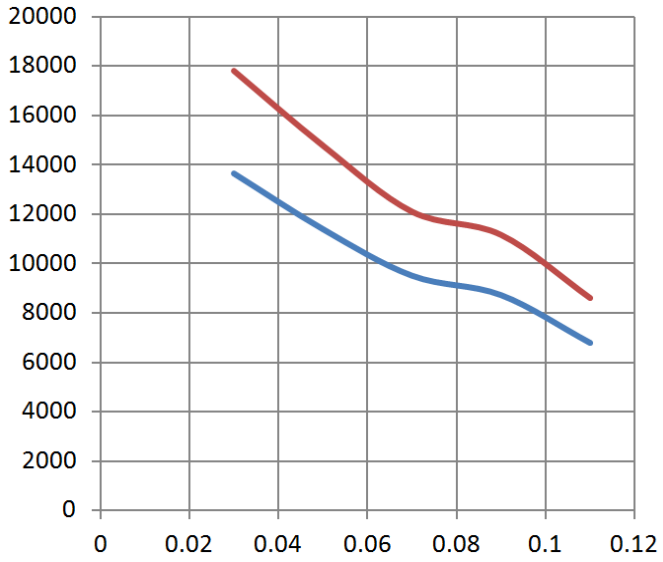
Dependence of fundamental and “second” resonance frequencies on clamping dimensions and diaphragms’ thickness. ANSYS FEA simulations

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT



Fundamental resonance frequency

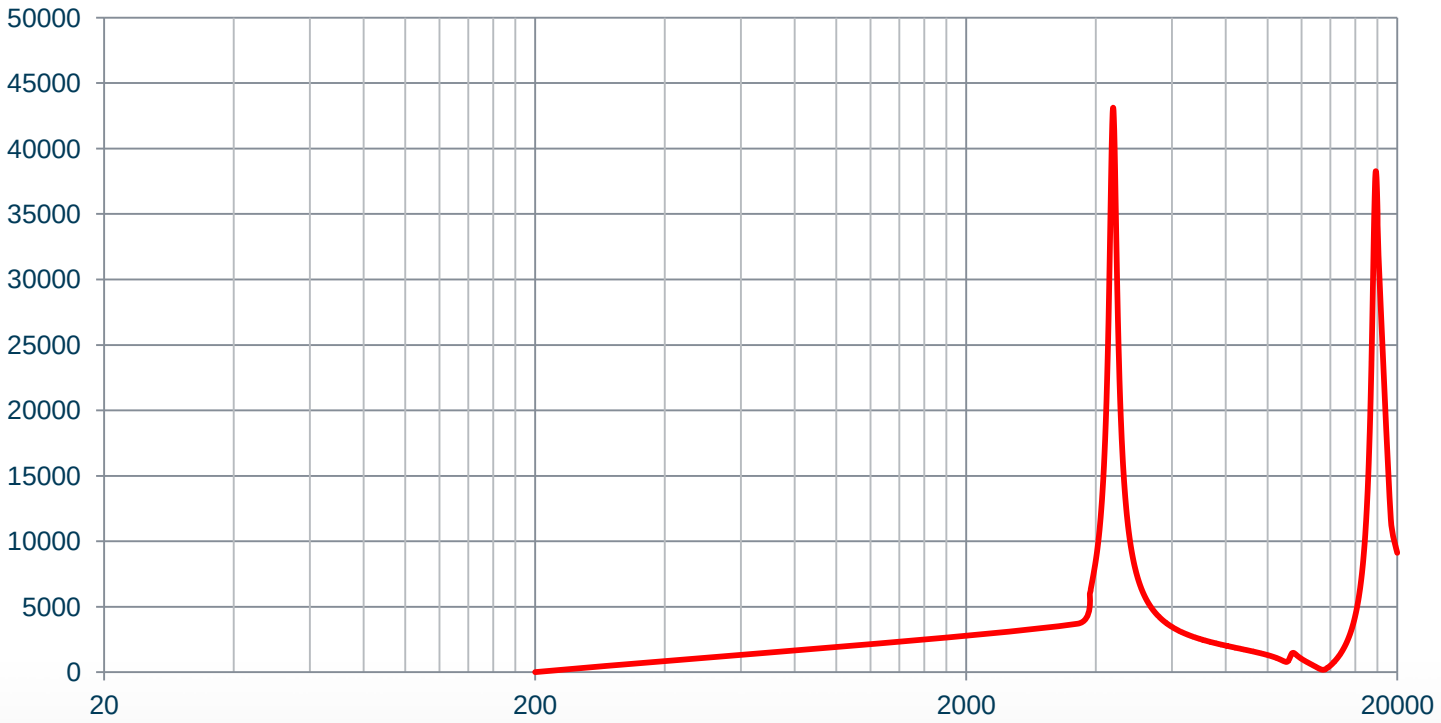


"Second" resonance frequency

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

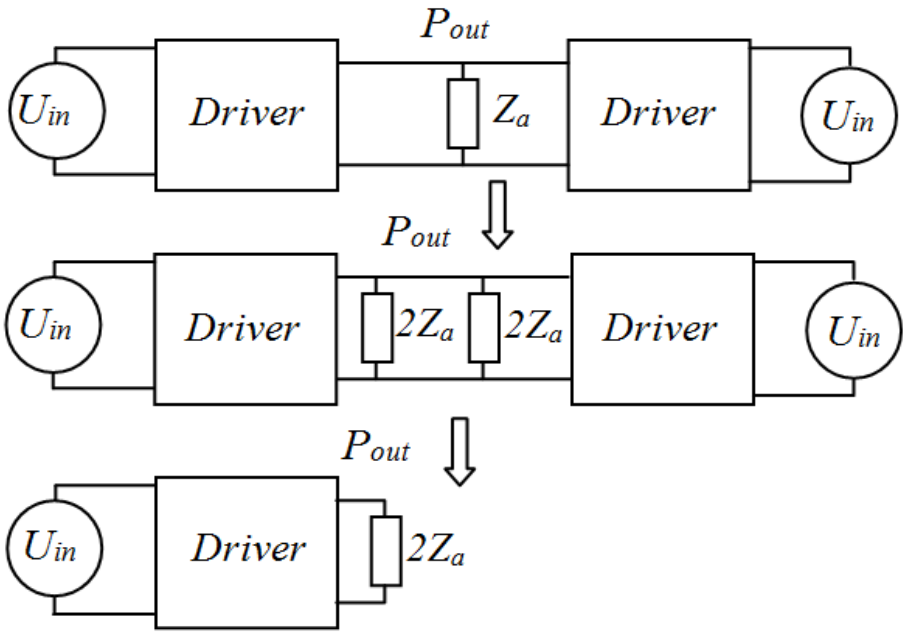
Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT



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

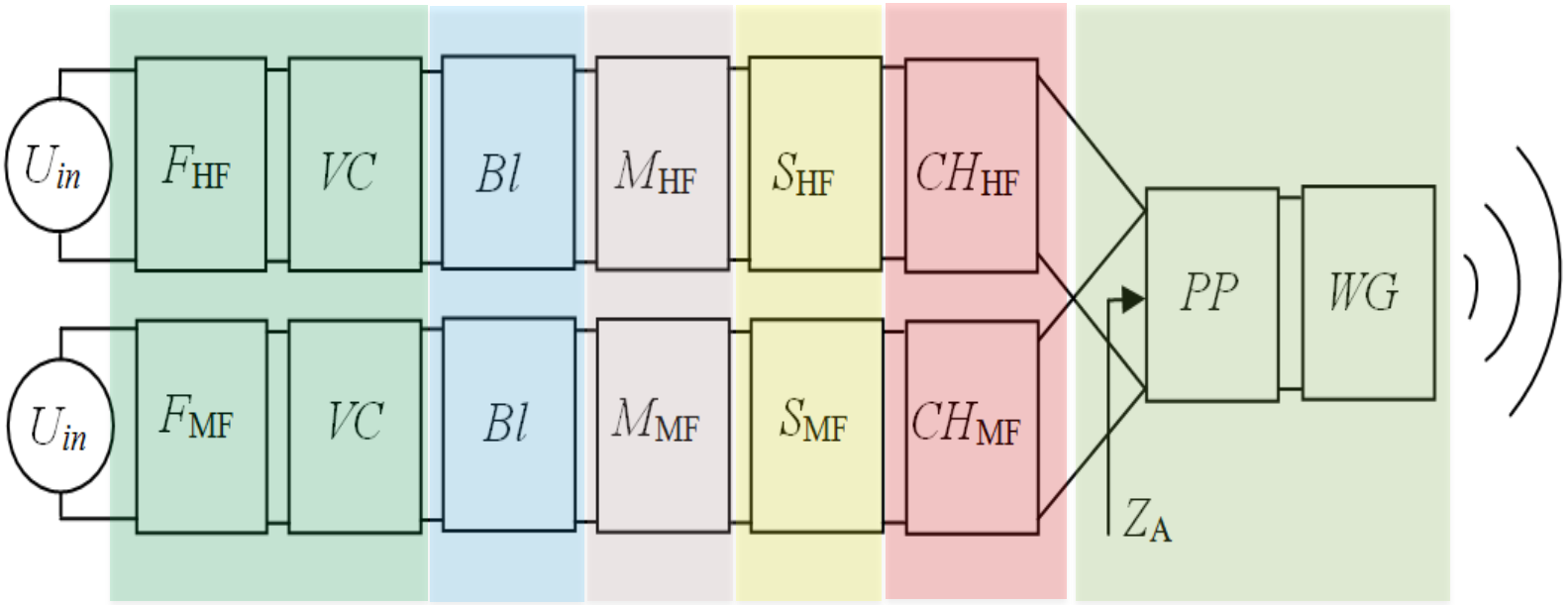
PREVIOUS CONCEPT



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

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

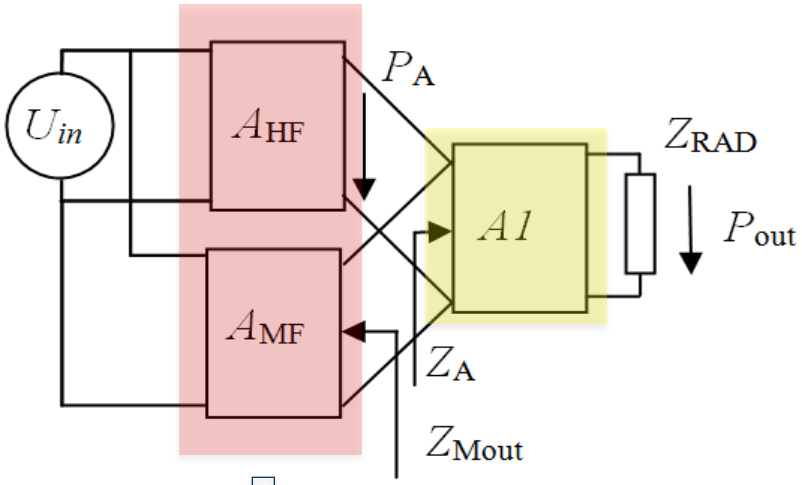


Matrix presentation of dual asymmetric compression driver

Dual Diaphragm Asymmetric Compression Drivers

(1)

NEW CONCEPT



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

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

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

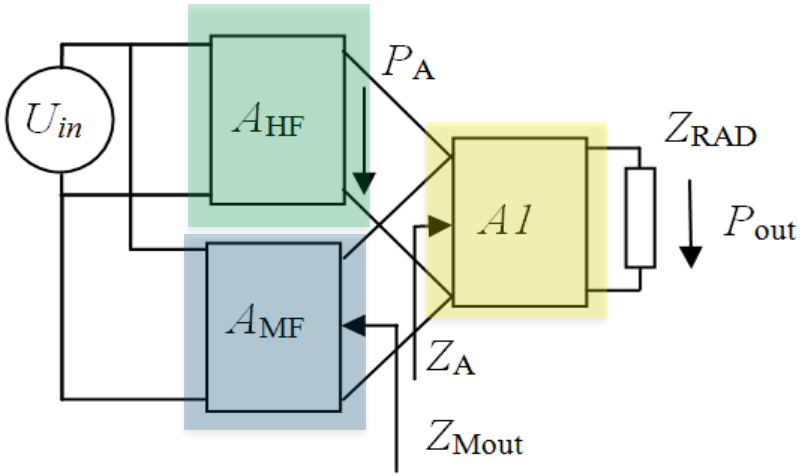
$$Y_{\Sigma} \Rightarrow A_{\Sigma}$$

A_{Σ}

$$P_A = \frac{U_{in}}{A_{\Sigma 11}A1_{11} + A_{\Sigma 12}A1_{12} + (A_{\Sigma 11}A1_{12} + A_{\Sigma 12}A1_{22}) / Z_{RAD}}$$

Modeling of the asymmetric dual driver sound pressure response

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

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

DA2420 Front View

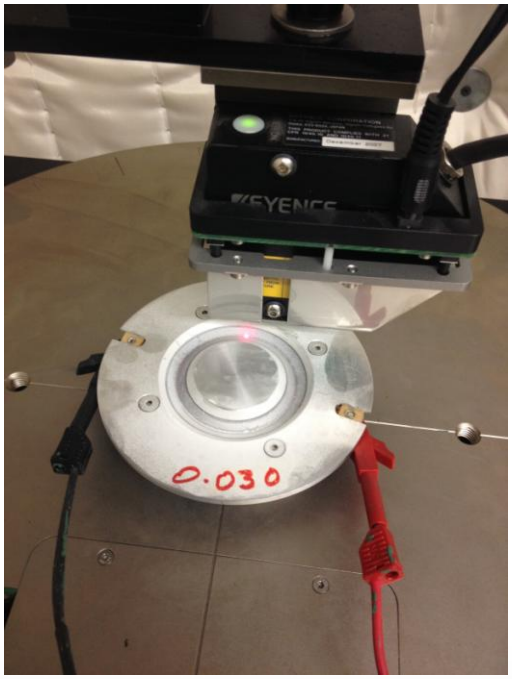
DA2420 Rear View

DA2420 loaded by Holland-Newell horn

Heatsink Prior Art

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

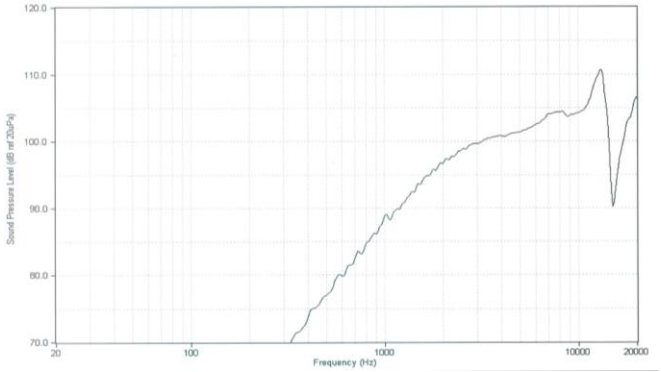


HF Open Diaphragm scanning by Klippel scanner

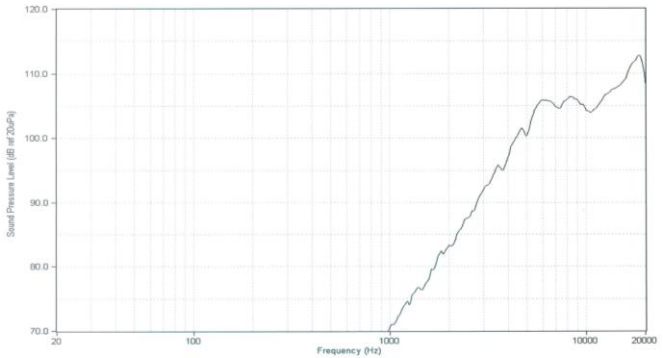
MF Open Diaphragm. 2Pi anechoic chamber measurement

Dual Diaphragm Asymmetric Compression Drivers

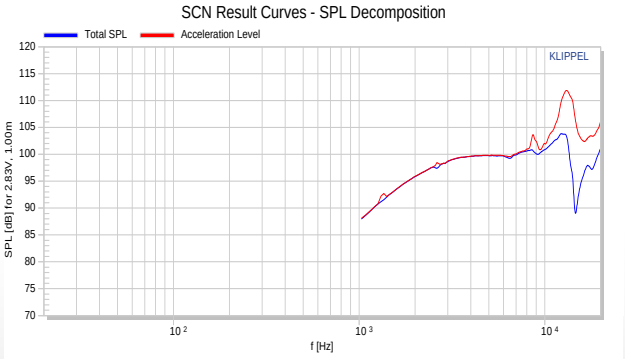
NEW CONCEPT



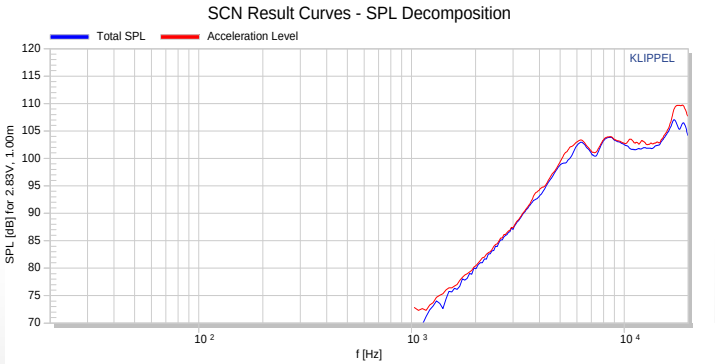
MF Open Diaphragm. Anechoic 2Pi chamber SPL response



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



MF Open Diaphragm. Klippel Scanner acceleration and SPL response

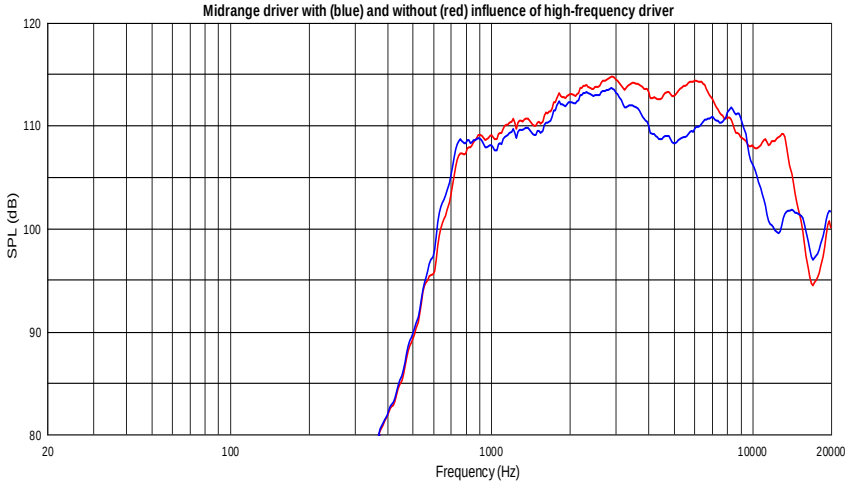


HF Open Diaphragm. Klippel Scanner SPL response simulation

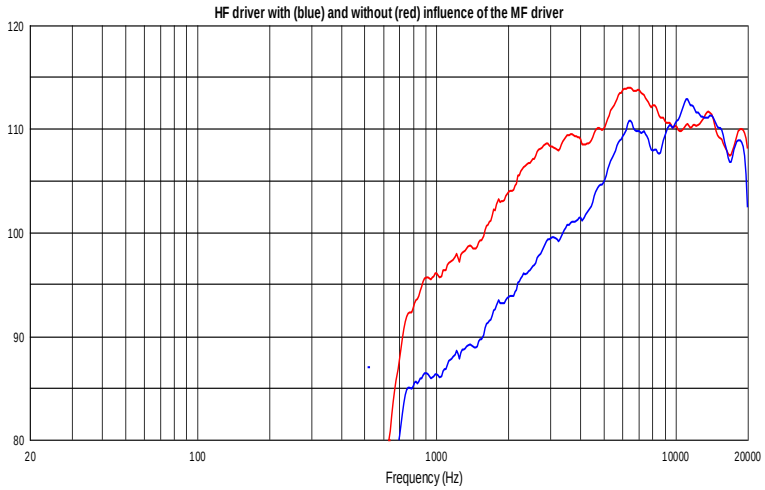
Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

Mutual influence of HF and MF drivers



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

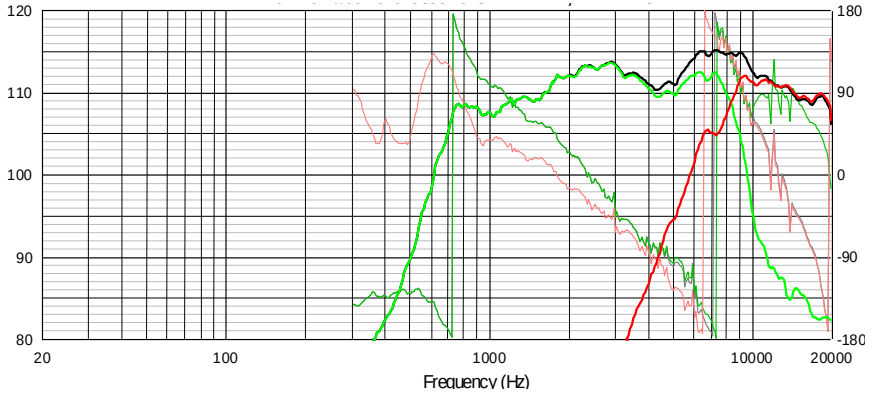


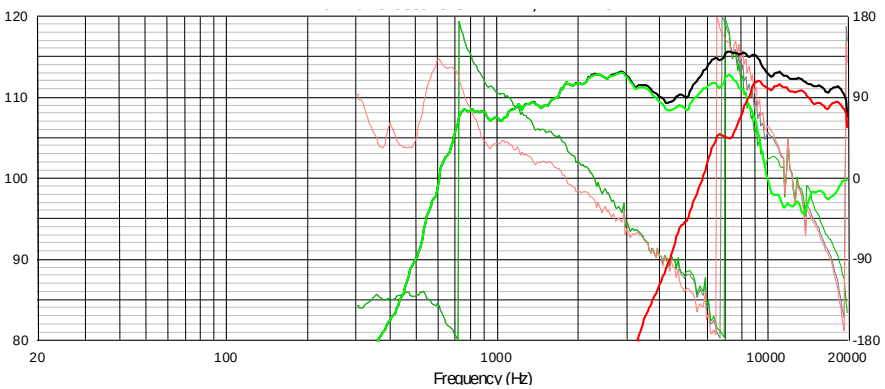
HF driver, SPL response. Red – single, blue – coupled with MF driver.

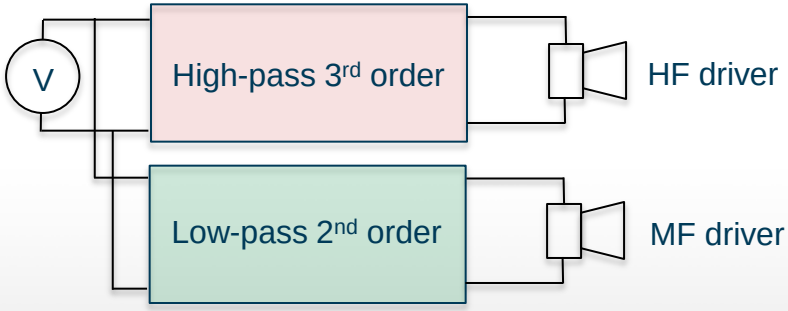
Dual Diaphragm Asymmetric Compression Drivers

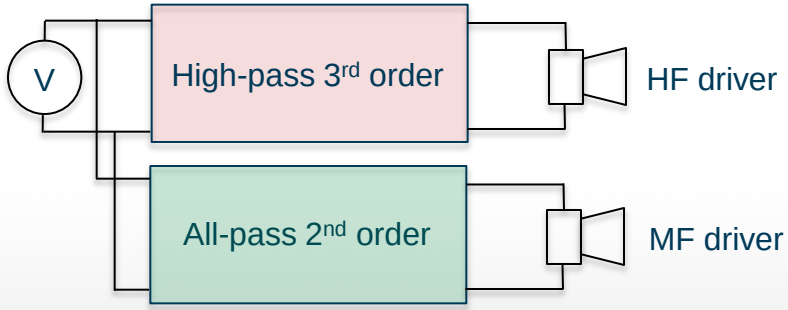
NEW CONCEPT

Active crossovers





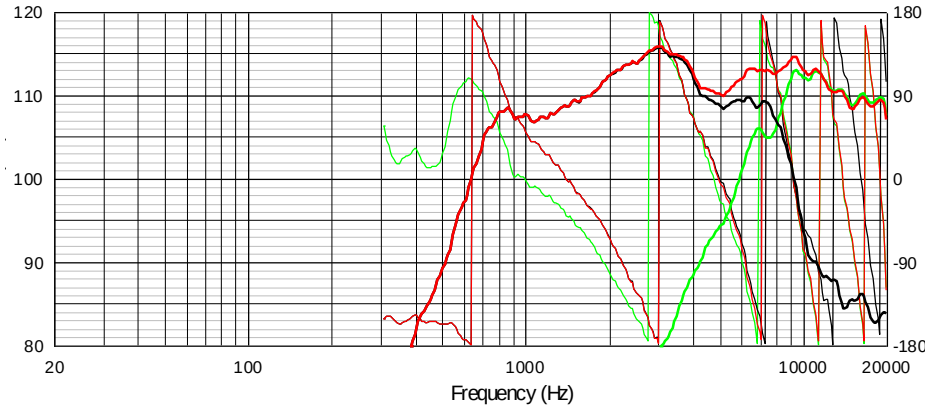


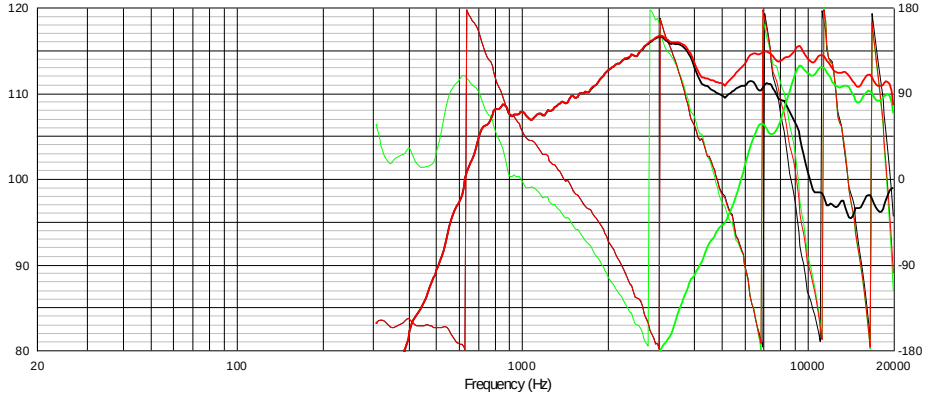


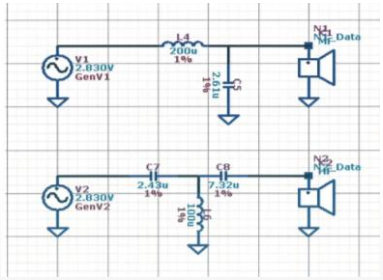
Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

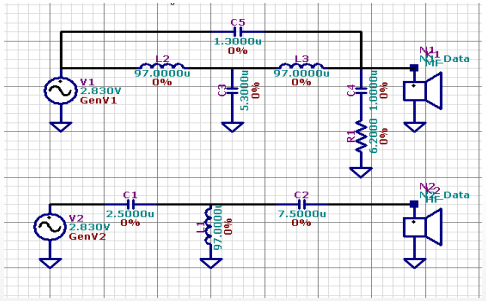
Passive crossovers







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



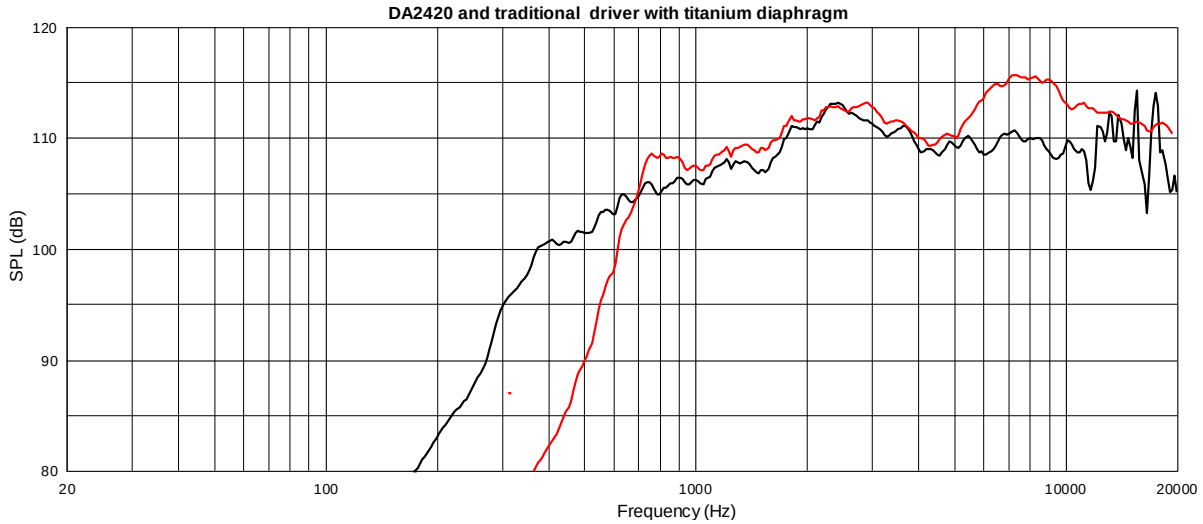
MF driver: All-pass 2nd order
HF driver – High-pass 3rd order

139th AES Convention, New York, October 30th 2015

Dual Diaphragm Asymmetric Compression Drivers

NEW CONCEPT

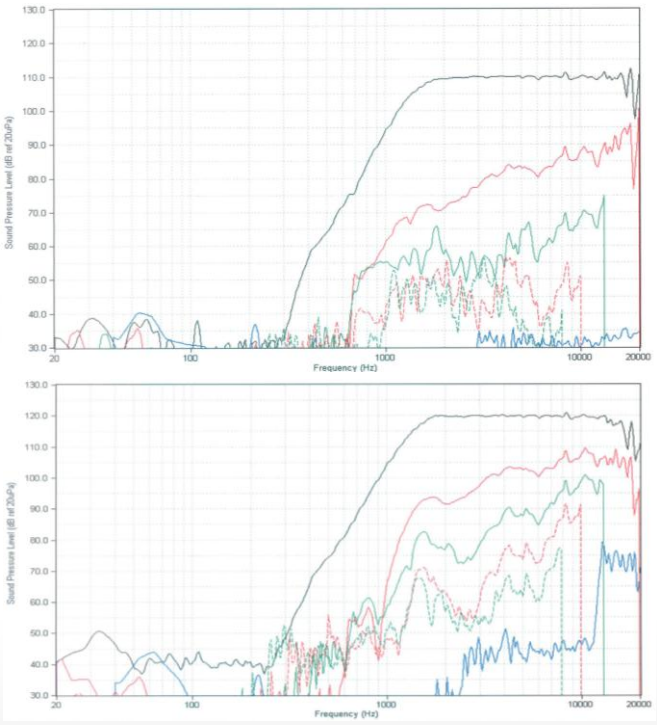
DA2420 and traditional driver with 3” titanium dome diaphragm



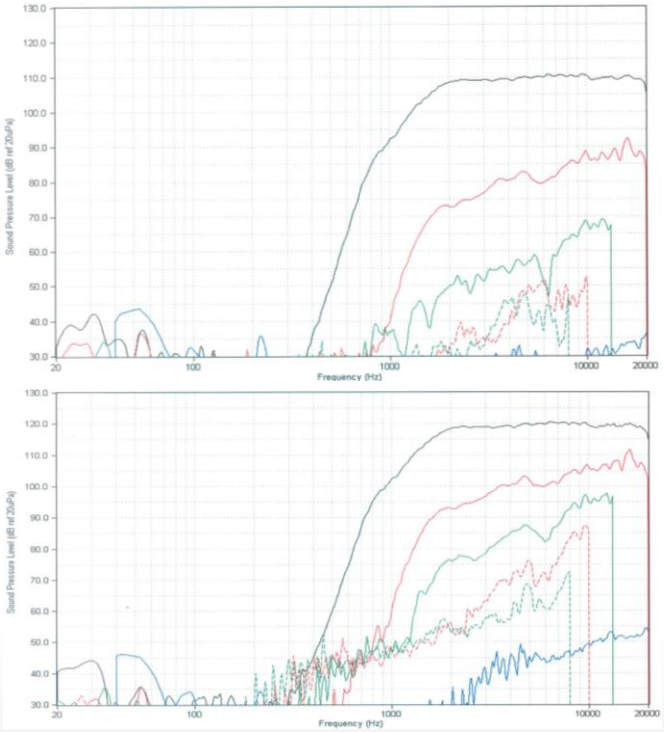
Red – DA2420. Blue – traditional driver with titanium dome diaphragm loaded by Holland-Newell axisymmetric horn. 2Pi anechoic chamber responses

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

139th AES Convention, New York, October 30th 2015

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