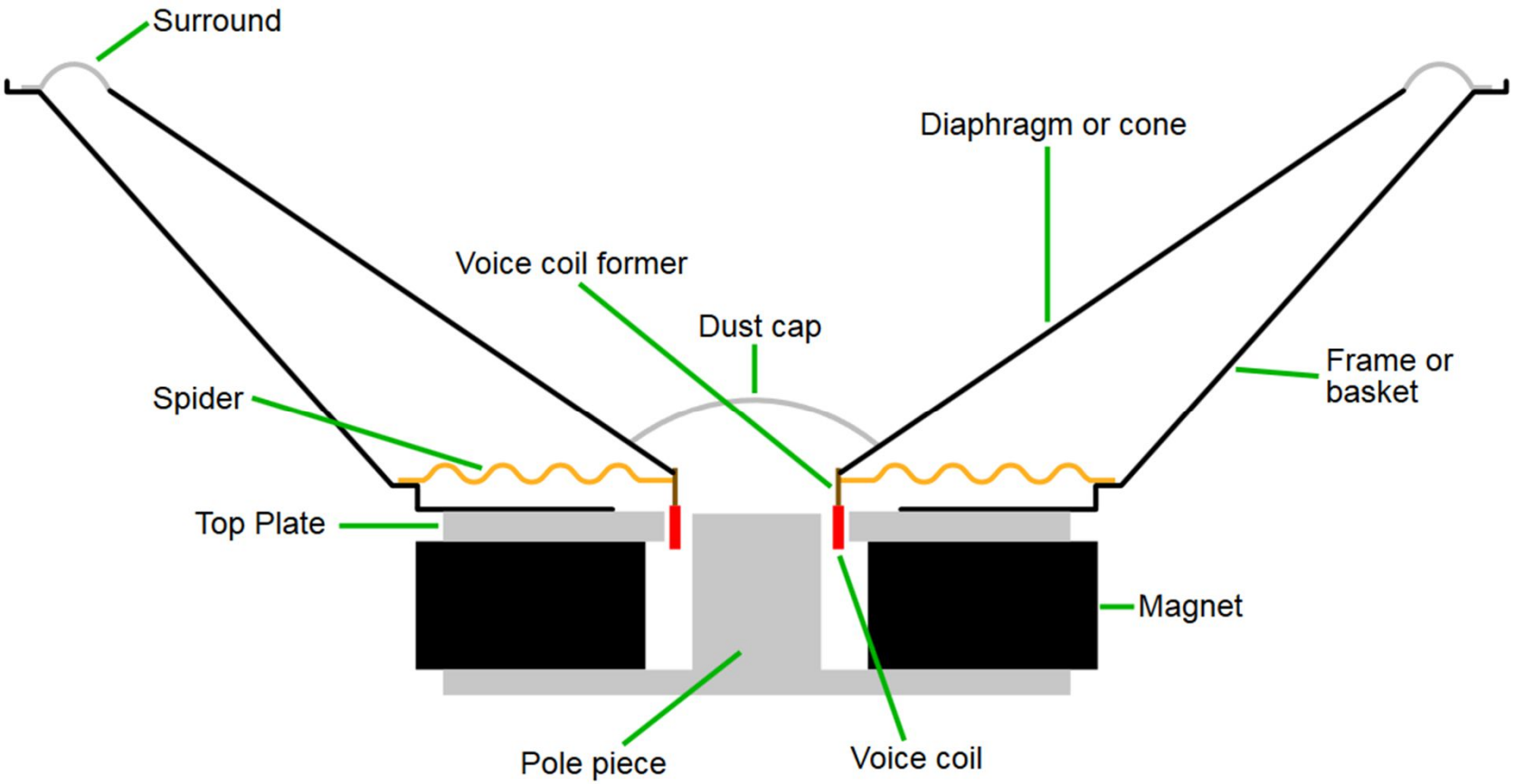
LOUDSPEAKERS

Study aid to learn Communication acoustics, VIHIAM 000

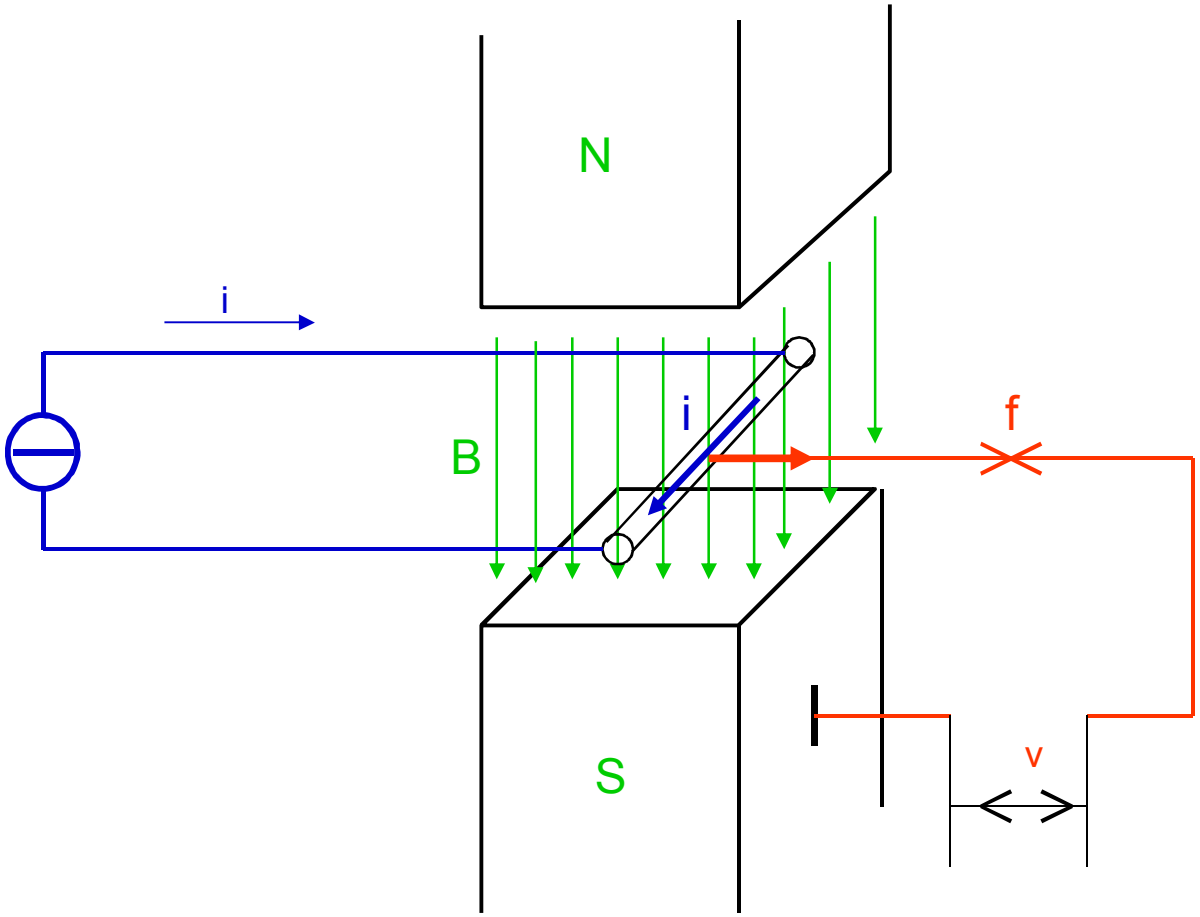
Prof. Fülöp Augusztinovicz
BME Networked Systems and Services
fulop@hit.bme.hu

2018. december 5.,
Budapest

The electrodynamic speaker



Principle of the electrodynamic transducer

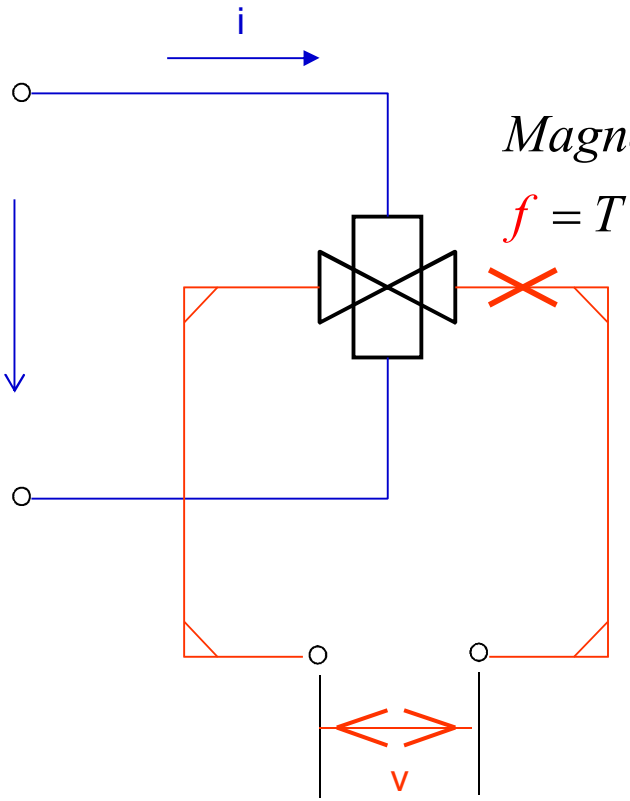


Blue line: electric conductor
Red line: mechanical connection

Electrodynamic transducer

Induktion law of Faraday :

$$u = \frac{d\Phi}{dt} = \frac{d(AB)}{dt} = \frac{l\,dx\,B}{dt} = Tv$$



Magnetic Lorentz force :

$$f = T\,i = B\,l\,i$$

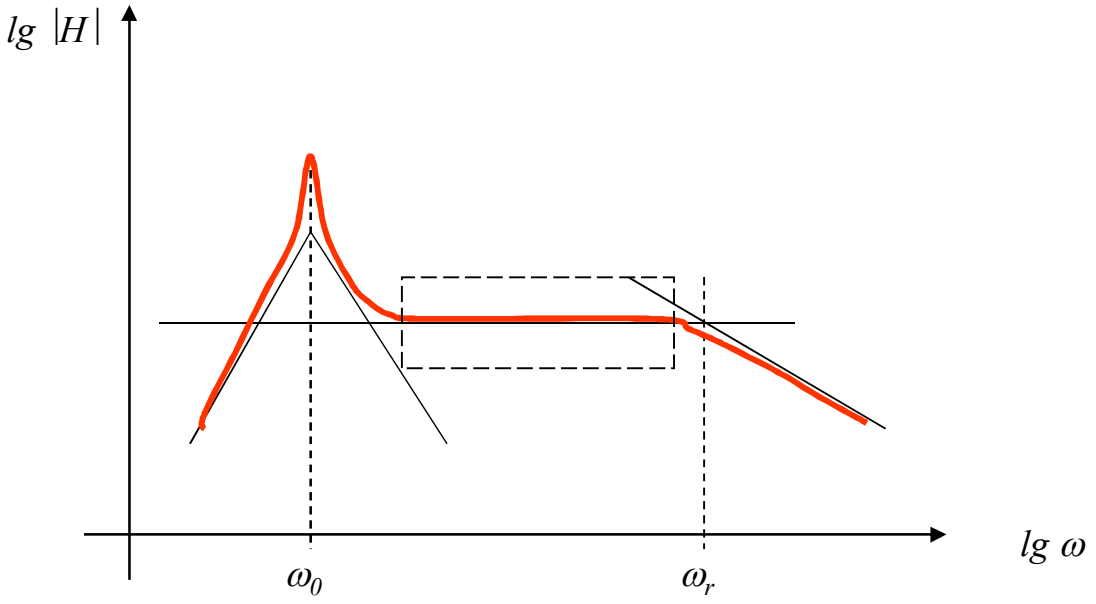
$$T = B\,l$$

Frequency response

$$H = \frac{f_s}{u} = \frac{T}{R}\frac{m_s}{m+m_s}\;\frac{\frac{s^2}{\omega_0^2}}{1+D\frac{s}{\omega_0}+\frac{s^2}{\omega_0^2}}\;\frac{1}{1+\frac{s}{\omega_r}}$$

ahol

$$\omega_0 = \frac{1}{\sqrt{c\left(m+m_s\right)}} \qquad \text{és} \qquad \omega_r = \frac{r_s}{m \times m_s}$$



Types of loudspeakers

- Woofer (low frequency)

Types of loudspeakers / 2

- Midrange

Tweeter

Types of loudspeakers / 3

- Coaxial (wide range)

Speaker column

Types of loudspeakers / 4

- Horn speaker

Building of speakers into boxes

- Why do we need speaker boxes? Acoustic shortcircuit!
- Usual ways of built:
  - baffle
  - Sealed box
  - Vented (or bass reflex) box
  - Subwoofer

Speaker box examples

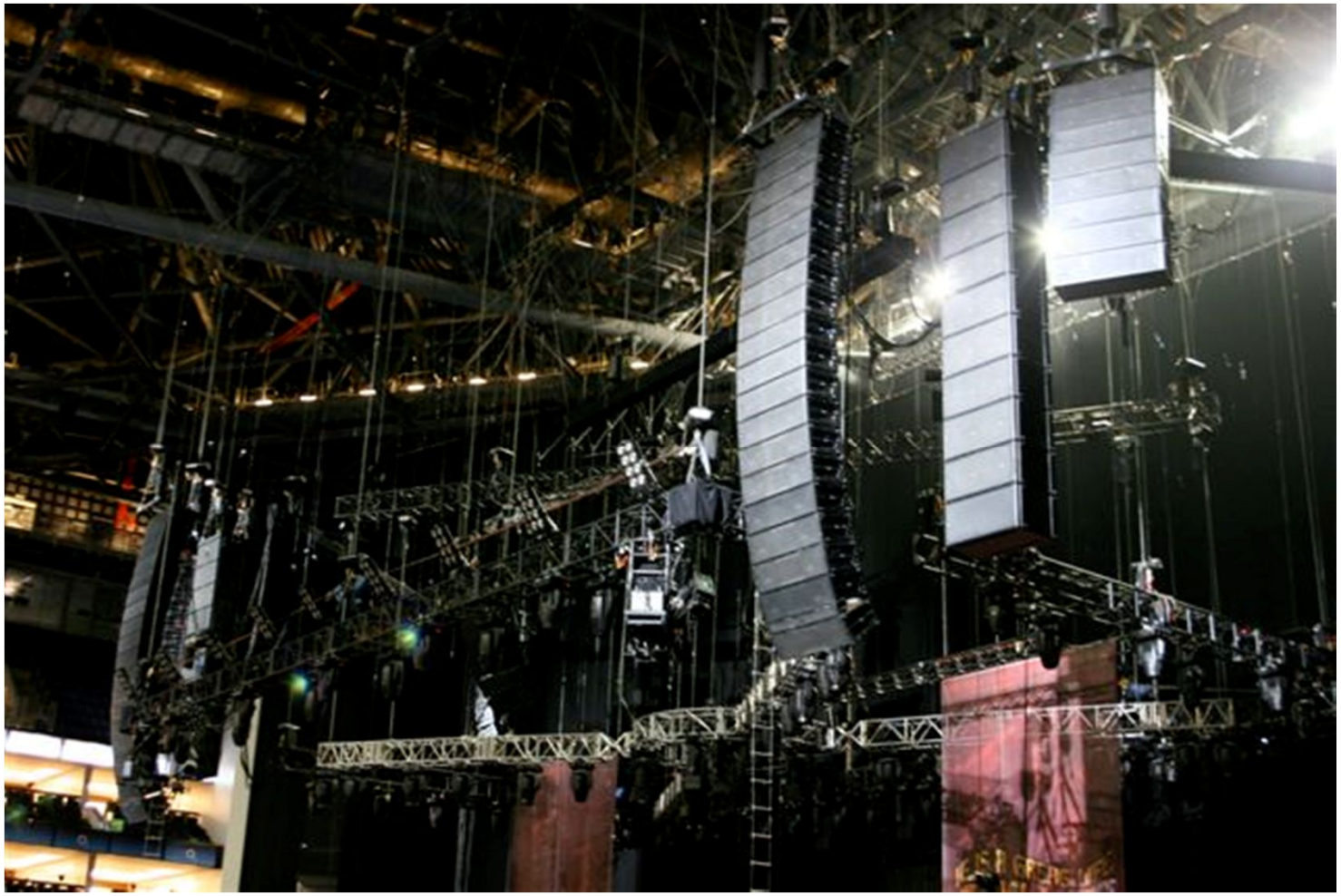
- 2-way, 3-way vented box

Speaker box examples / 2

- Subwoofer

Speaker box examples / 3

- Linear array, cluster

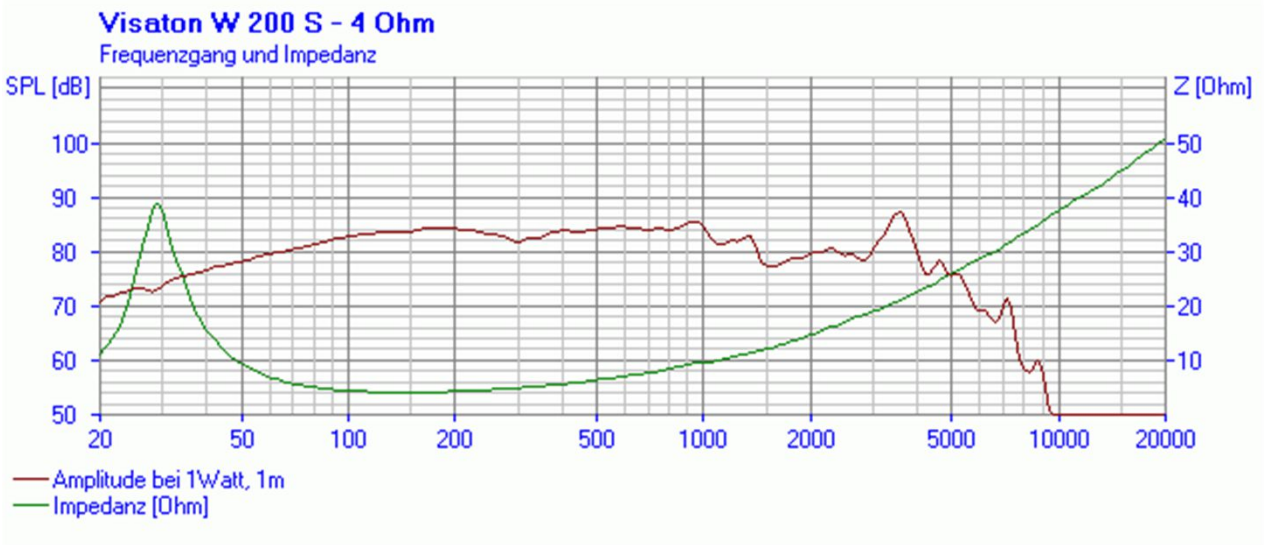


Specification of speakers

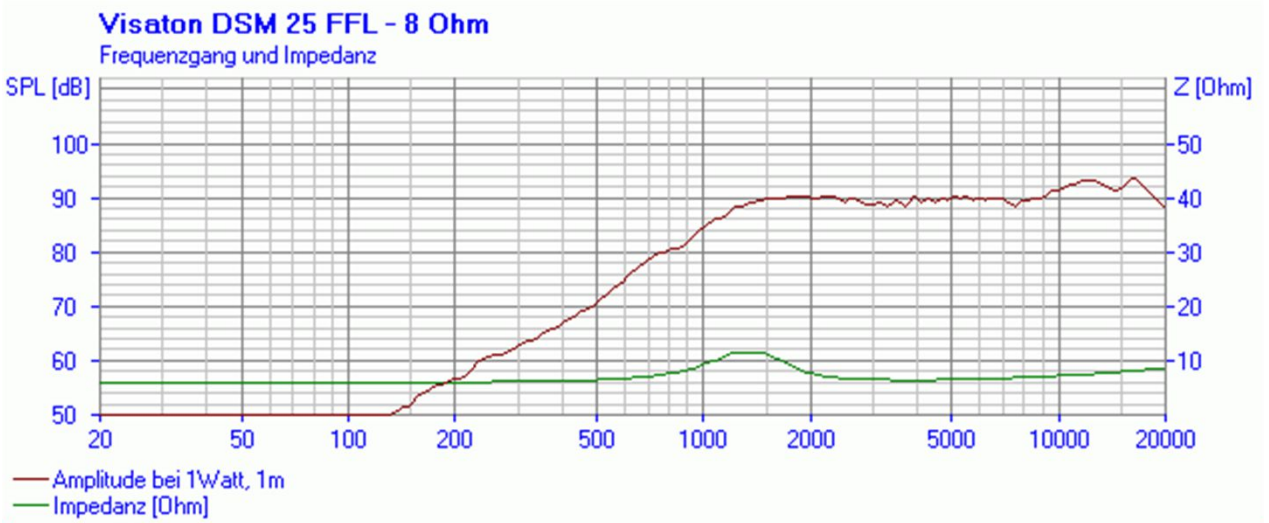
- Max. electric power, **W** – not equal to what is radiated acoustically!
  - Sinusoidal, musical, but always continuous – not short time power handling capability! (PMPO – peak maximum power output)
- $\eta = P_{acoustici}/P_{electric} = 4\text{-}20\%$!
- Impedance, **ohm**
  - Impedance, looked into the speaker from the electric connections. Absolute value for the center frequency of specified frequency range
- Sensitivity, **dB**
  - Sound pressure level in dB, measured for sinusoidal input signal corresponding to 1W electric input power at nominal impedance, at 1m distance in the axle of the speaker, for center frequency
- Frequency response, **dB vs. f**
  - Relative SPL in the axle at 1m, as a function of sinusoidal frequency
- Directivity, **dB vs.** φ
  - Relative SPL at 1m distance in various directions, with f as parameter
- Distortion, **%**
  - Total amplitude of higher harmonics, as a ratio related to the ground tone. Parameters are frequency and input electric power.

Frequency response / 1

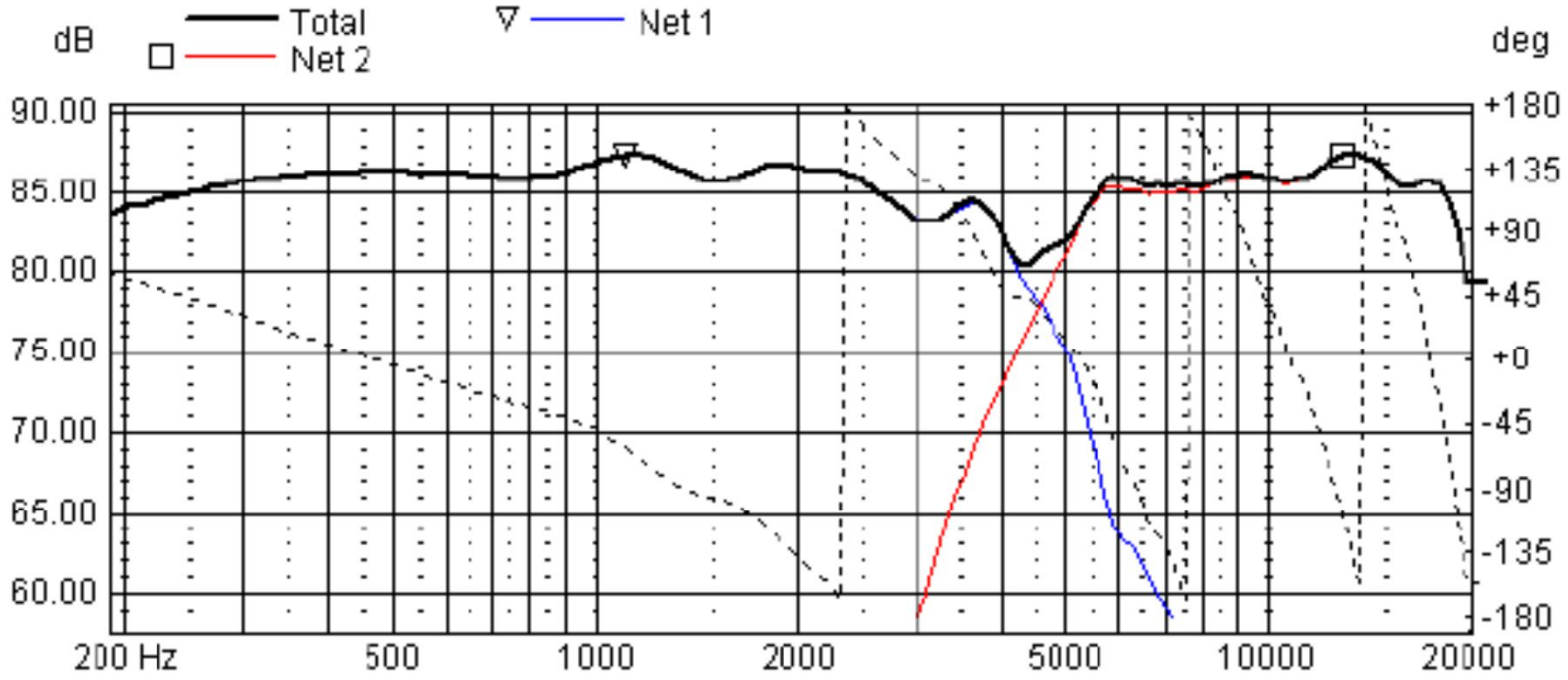
- Woofer-midrange



- tweeter

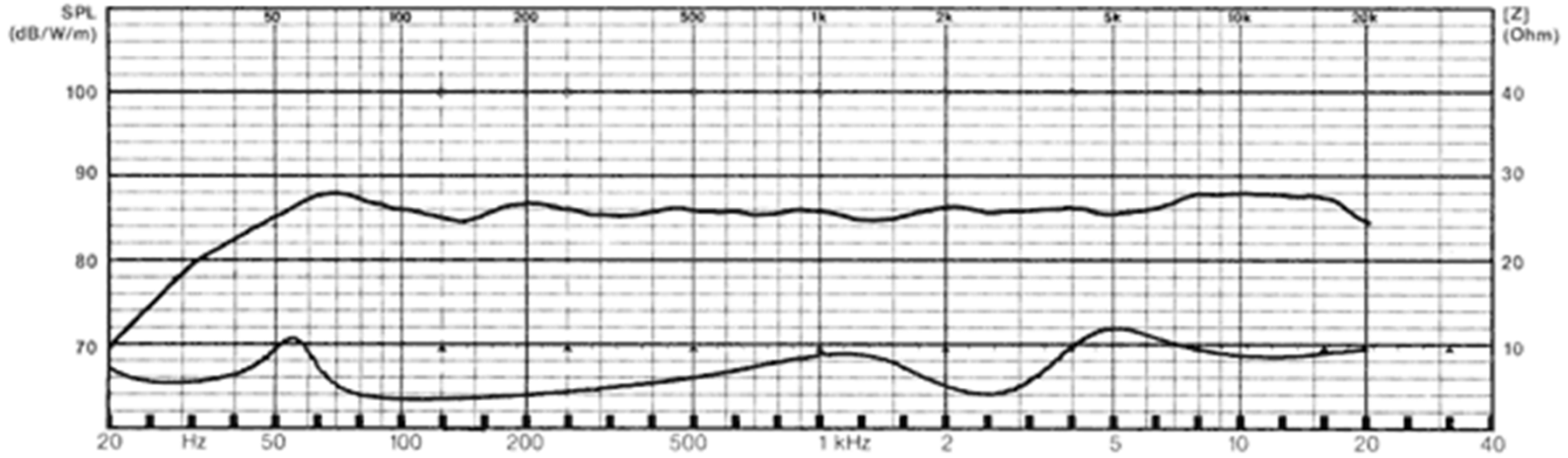


Crossover

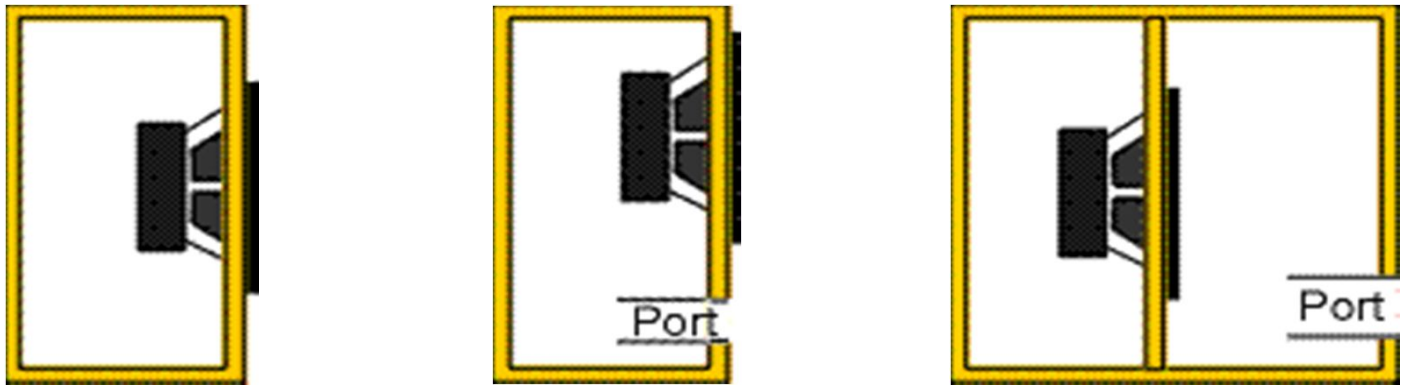

dB
Total
Net 1
Net 2
deg
90.00
85.00
80.00
75.00
70.00
65.00
60.00
+180
+135
+90
+45
+0
-45
-90
-135
-180
200 Hz
500
1000
2000
5000
10000
20000

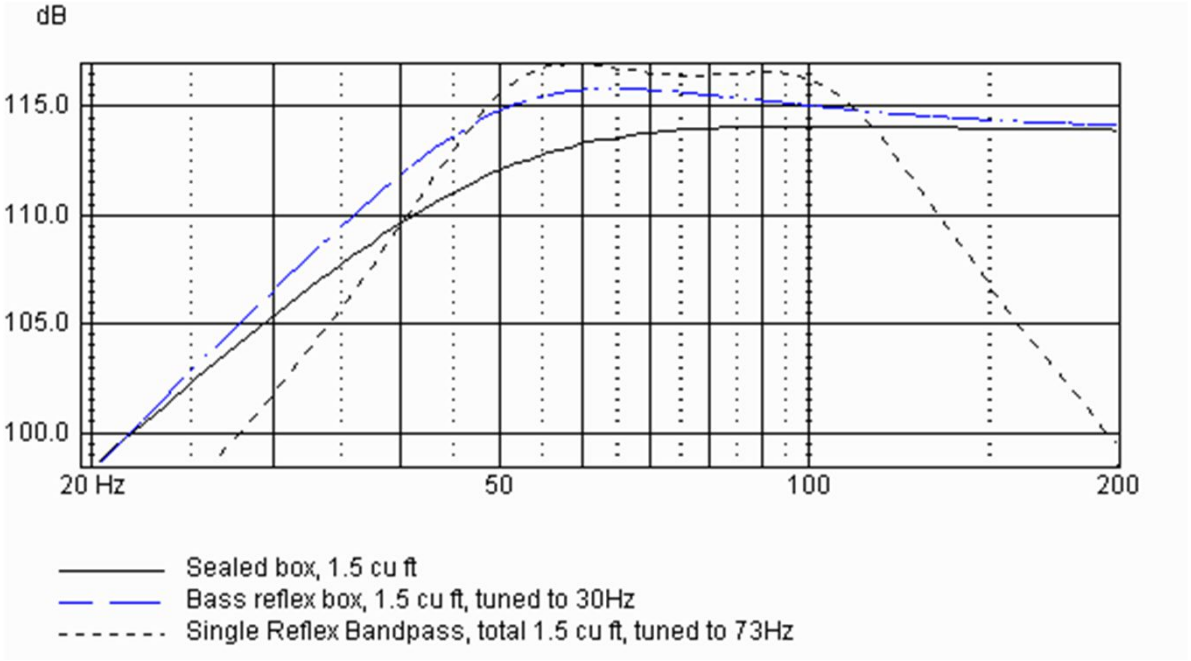
Frequency response / 2

- 3-way combined speaker box



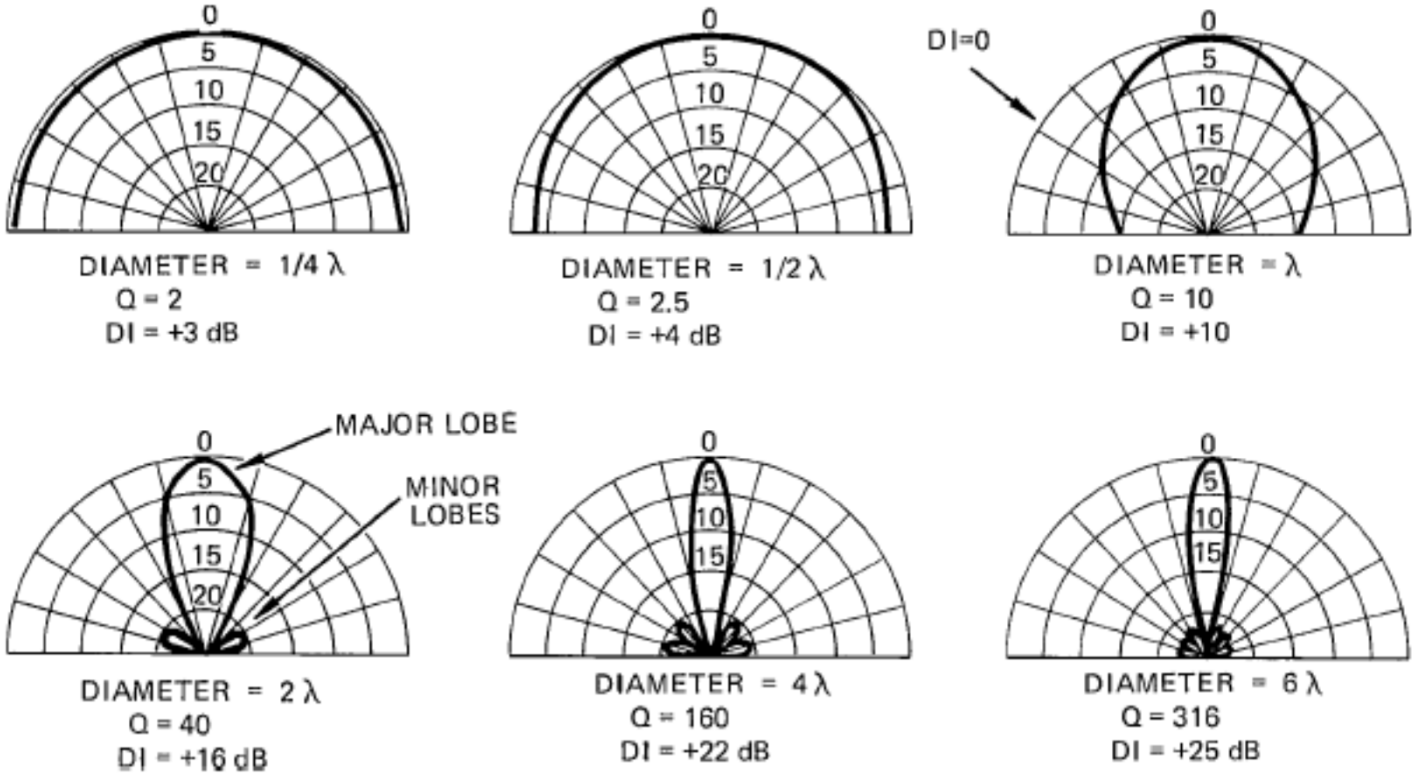
Comparison of FRFs





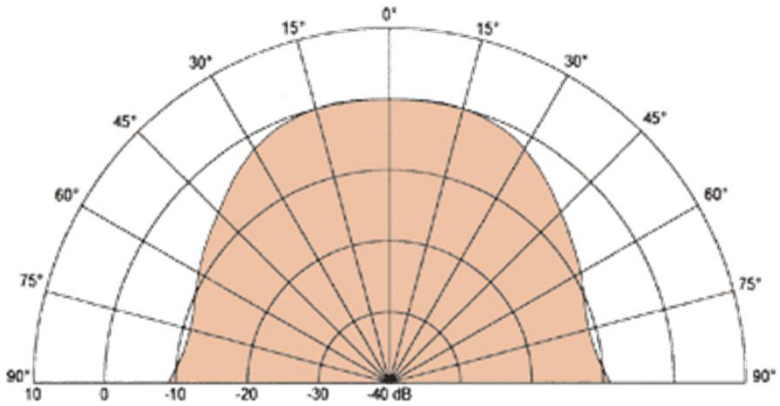
Directional/polar characteristics / 1

Round, ideal piston in infinite baffle, for various relative size wrt wavelength



Directional/polar characteristics / 1

- Tweeter



The effect of the listening room

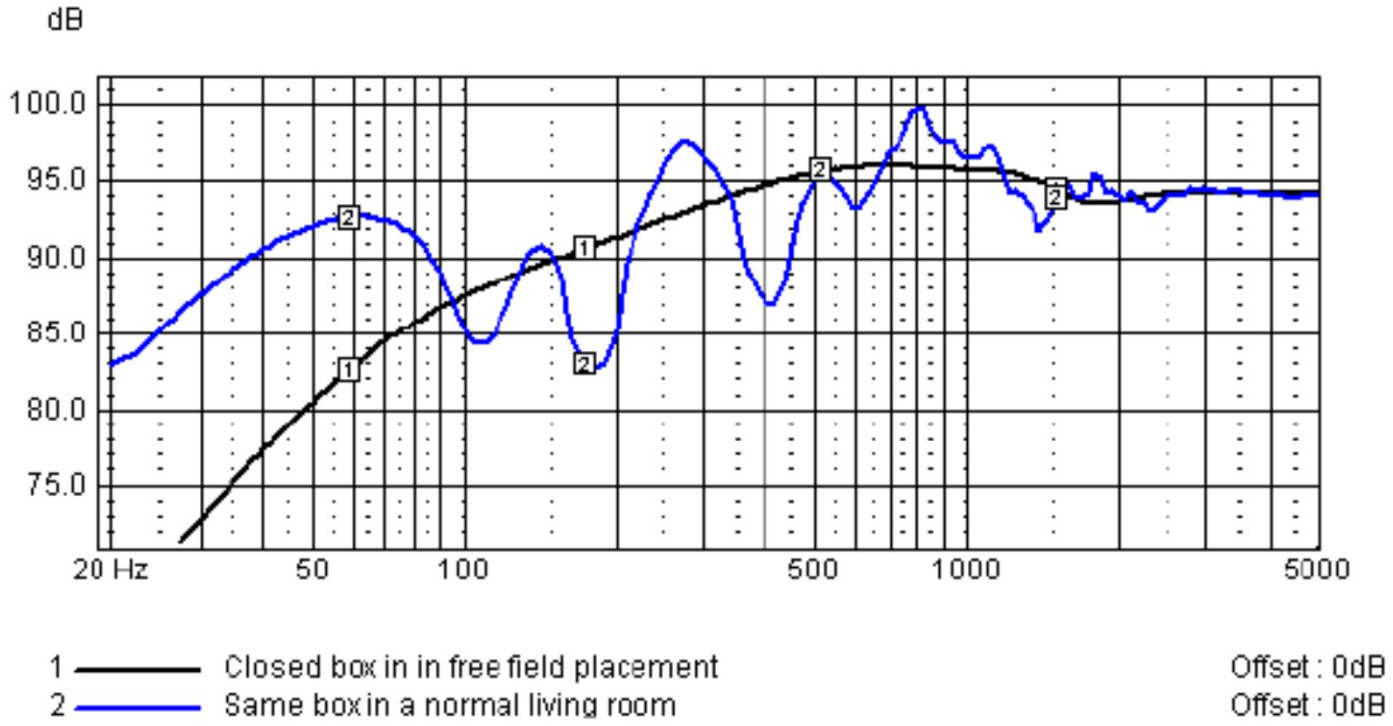
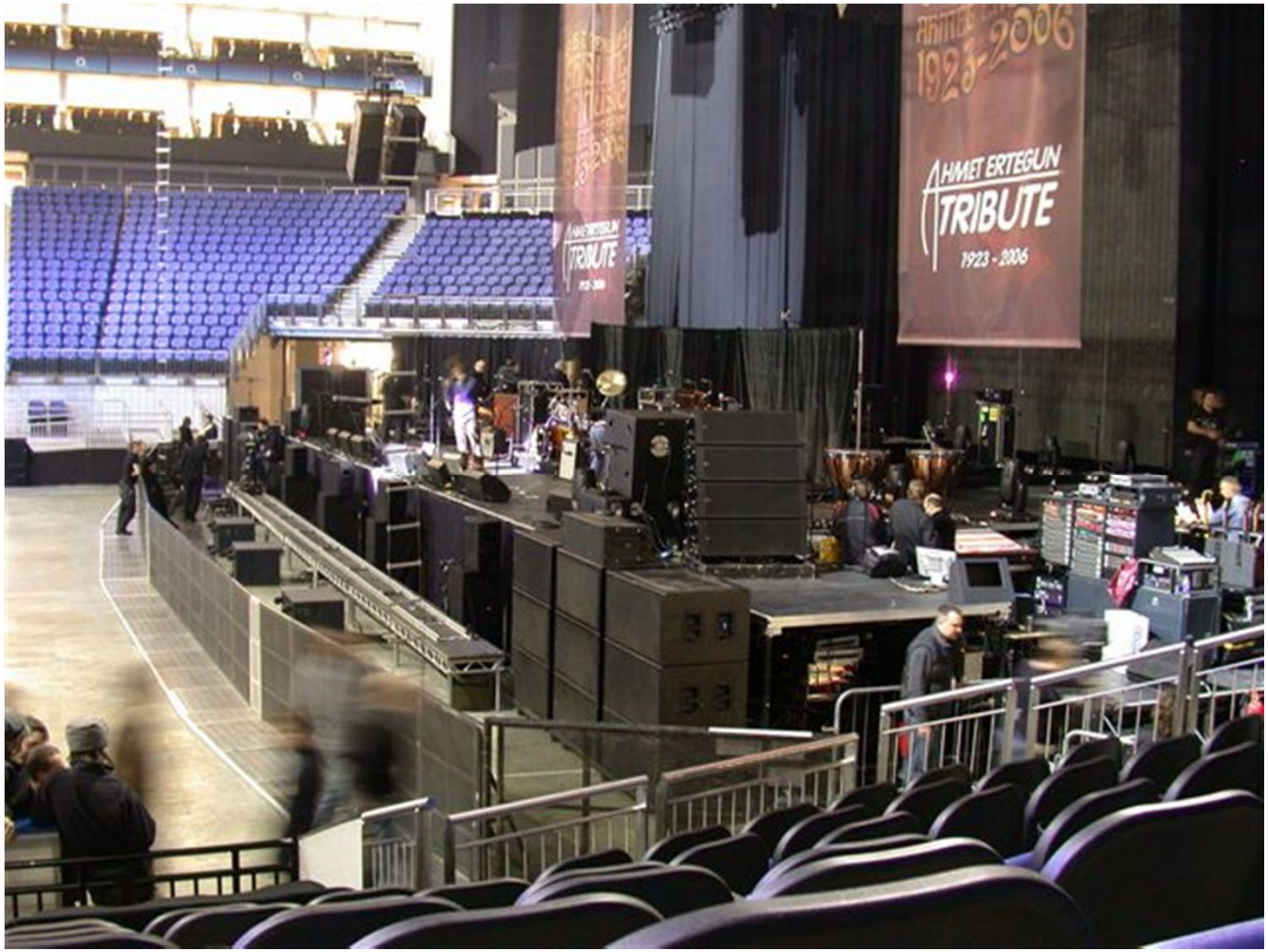


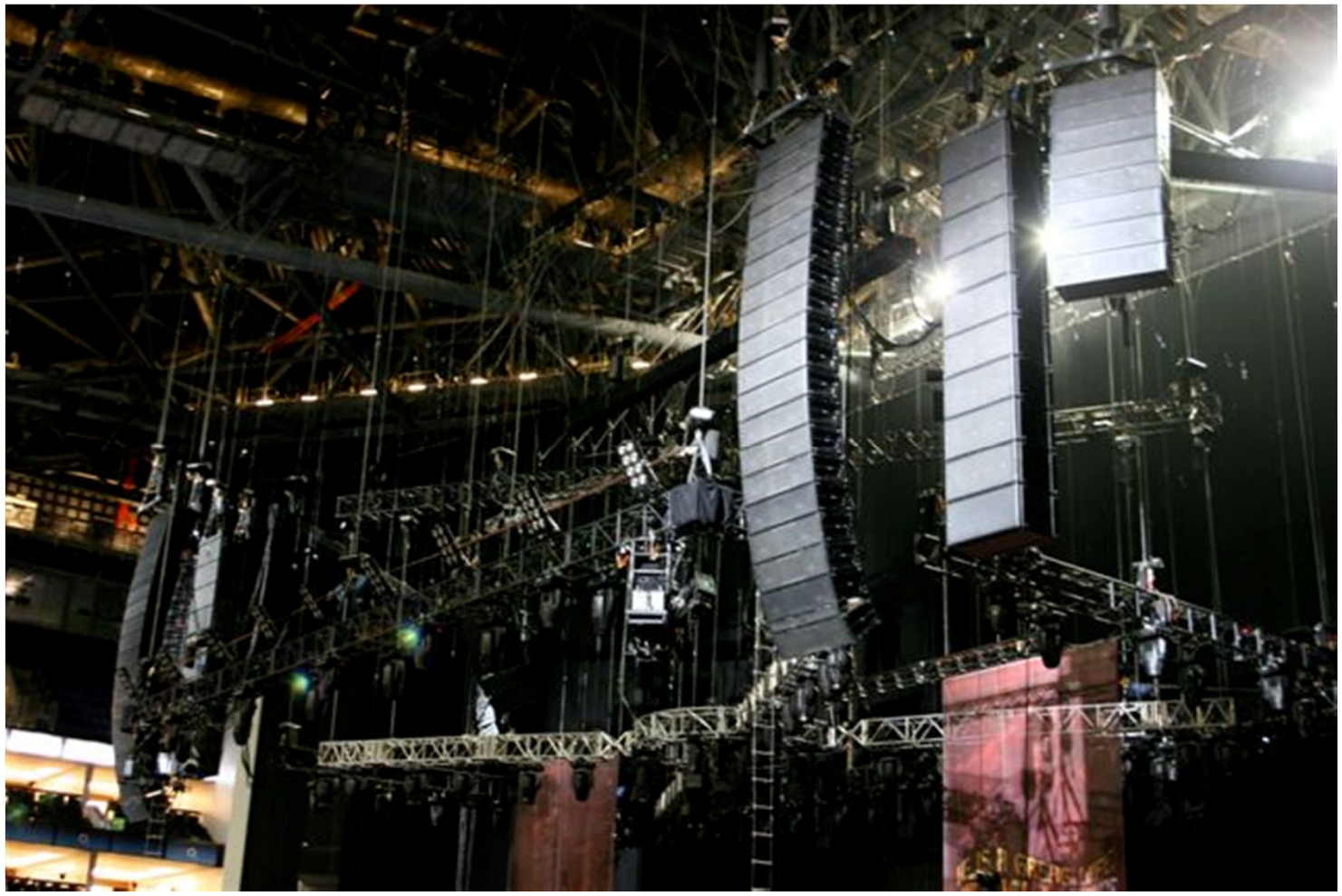
Fig. 29. Simulated loudspeaker response, both free air and in living room.

Basic principles of sound reinforcement systems



Complex radiators, clusters

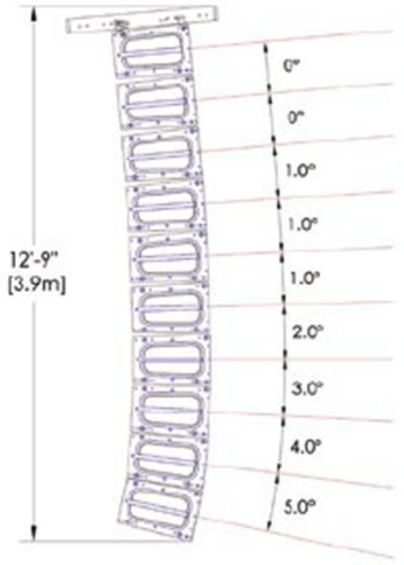
- Linear array, cluster

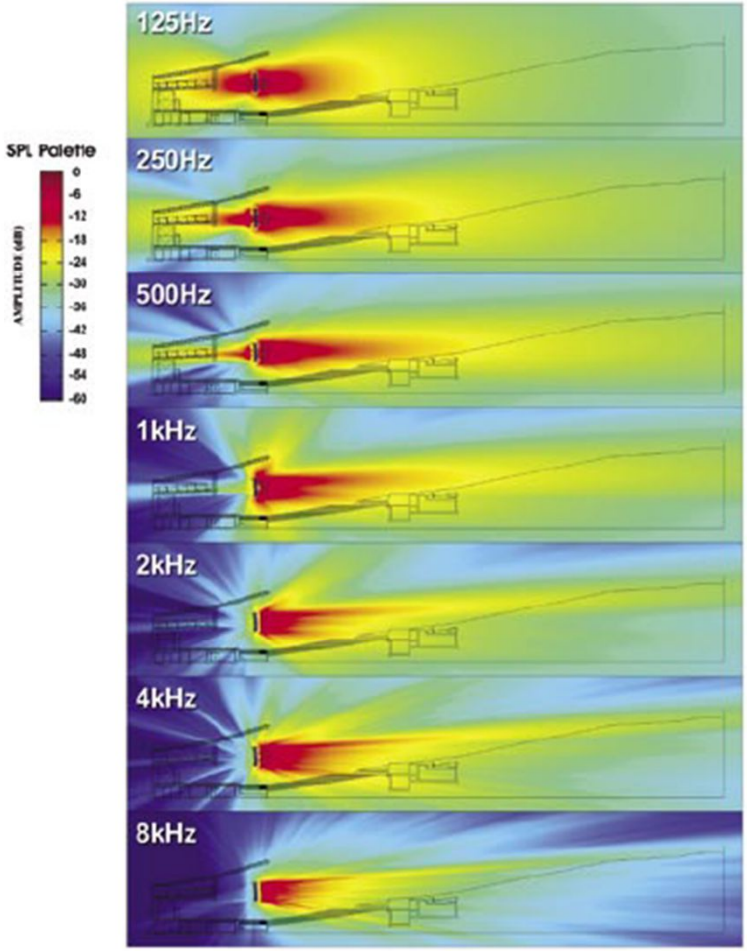


Radiation from curvilinear speaker array

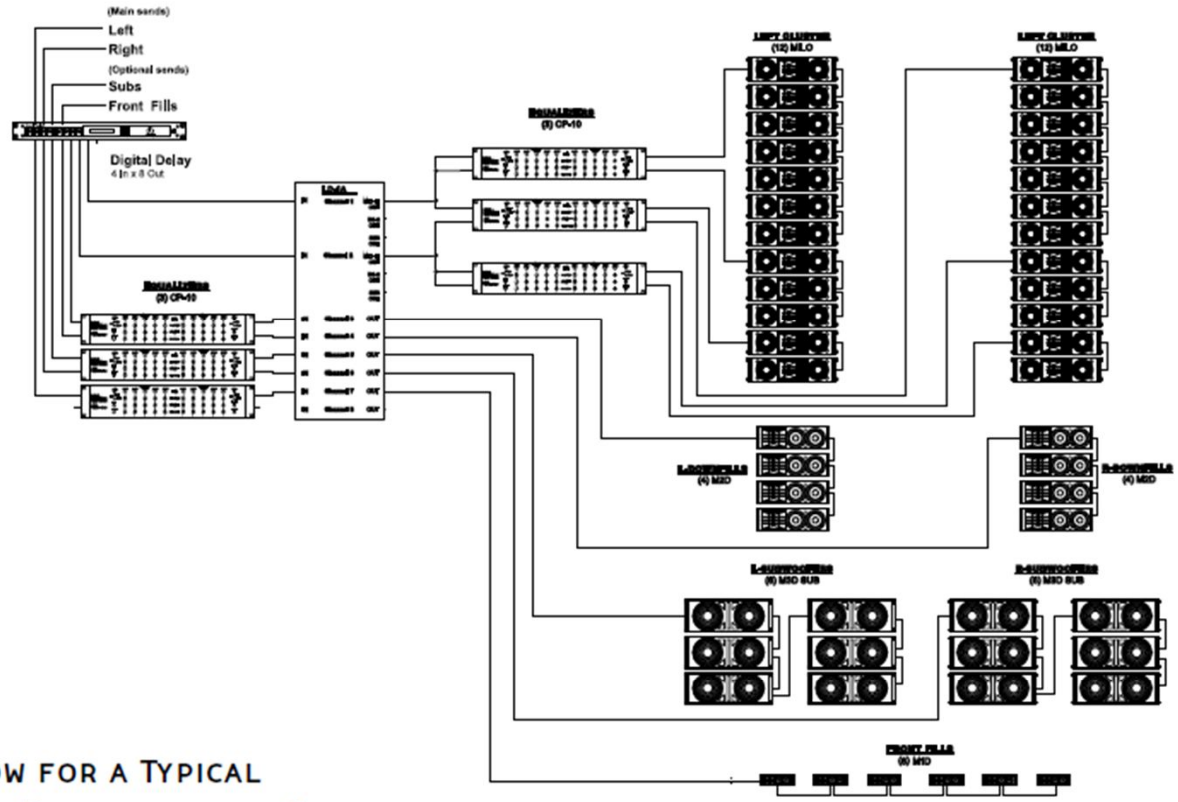
MILO Vertical Splay and Coverage

These illustrations show how the splay between adjacent cabinets in a MILO array may be adjusted to tailor coverage for a specific venue. The MAPP Online plots on the right illustrate the vertical directivity characteristics of the array on the left, with a section view of the venue superimposed.





A bit of professional system design



SIGNAL FLOW FOR A TYPICAL INTEGRATED REINFORCEMENT SYSTEM

Because the MILO loudspeaker is compatible with most other Meyer Sound reinforcement loudspeakers, sound designers have maximum freedom to customize systems for their needs. This block diagram illustrates the signal flow for a typical integrated sound reinforcement system using 12 MILOs per side for the main arrays.

Surround sound systems

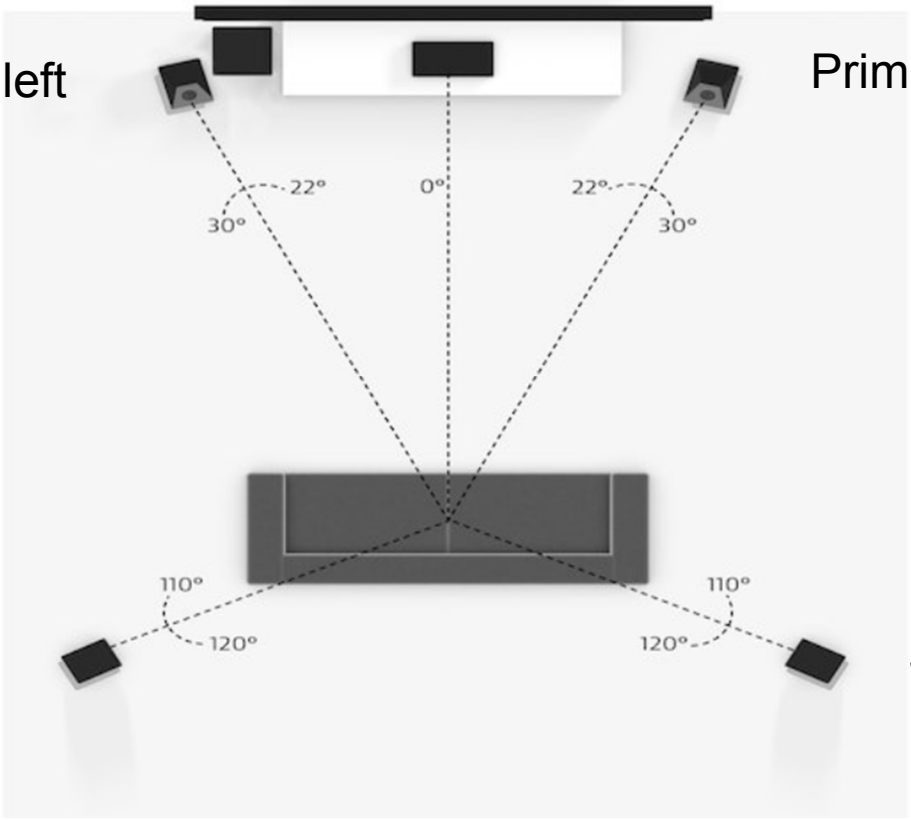
- 5.1 home theater sound system

Optimum positioning of the speakers

Center

Primary left

Primary right



Surround left

Surround right

Optimum positioning of the speakers

- 7.1 home theater system (extra left and right back speakers)