Multimedia Technology – labs in audio technology

1) Measurement of acoustic power radiated by a loudspeaker

2) Measurement of input electric impedance of a loudspeaker in a closed and bass-reflex enclosures

3) Measurement of sound absorption coefficient

4) Audio signals and their assesment

Measurement of acoustic power radiated by a loudspeaker

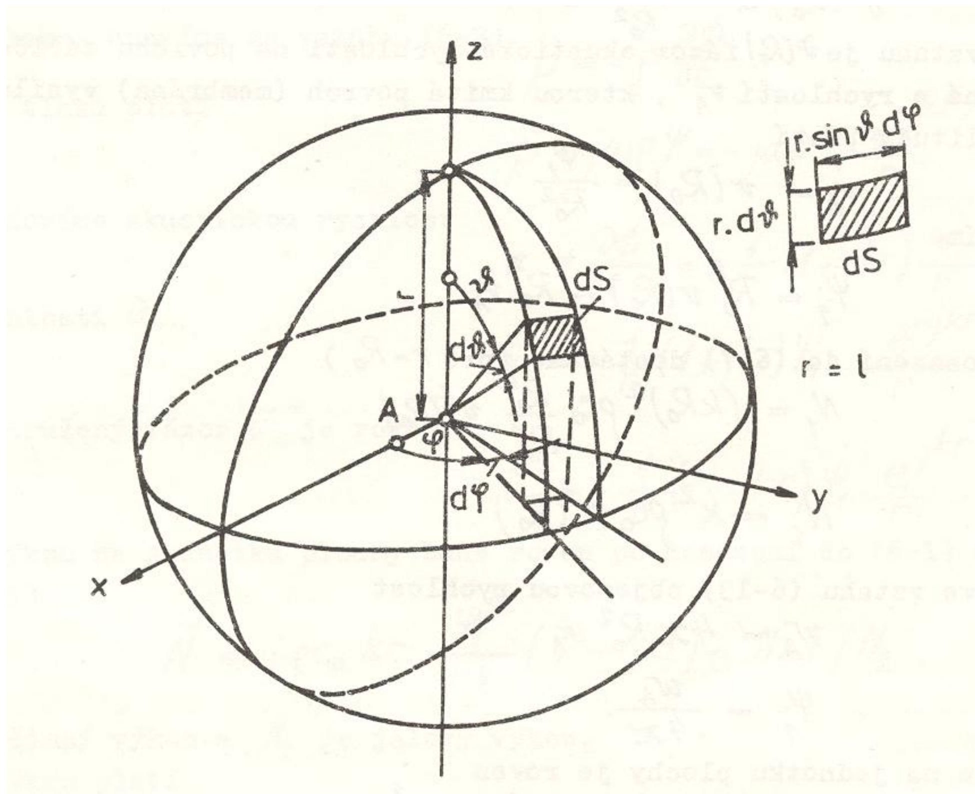
$$P = \vec{F}.\vec{v} = p.\vec{S}.\vec{v} = p.v.S.\cos(\psi)$$

P is the power, F force, v velocity, S surface, ψ phase angle

On condition of in-phase quantities (plase wave):

$$dP = IdS = p_{ef}\,v_{ef}\,dS = \frac{p_{ef}^2}{\rho c_0}dS$$

$$P = \frac{1}{\rho c_0}\oiint_S p_{ef}^2\,dS$$



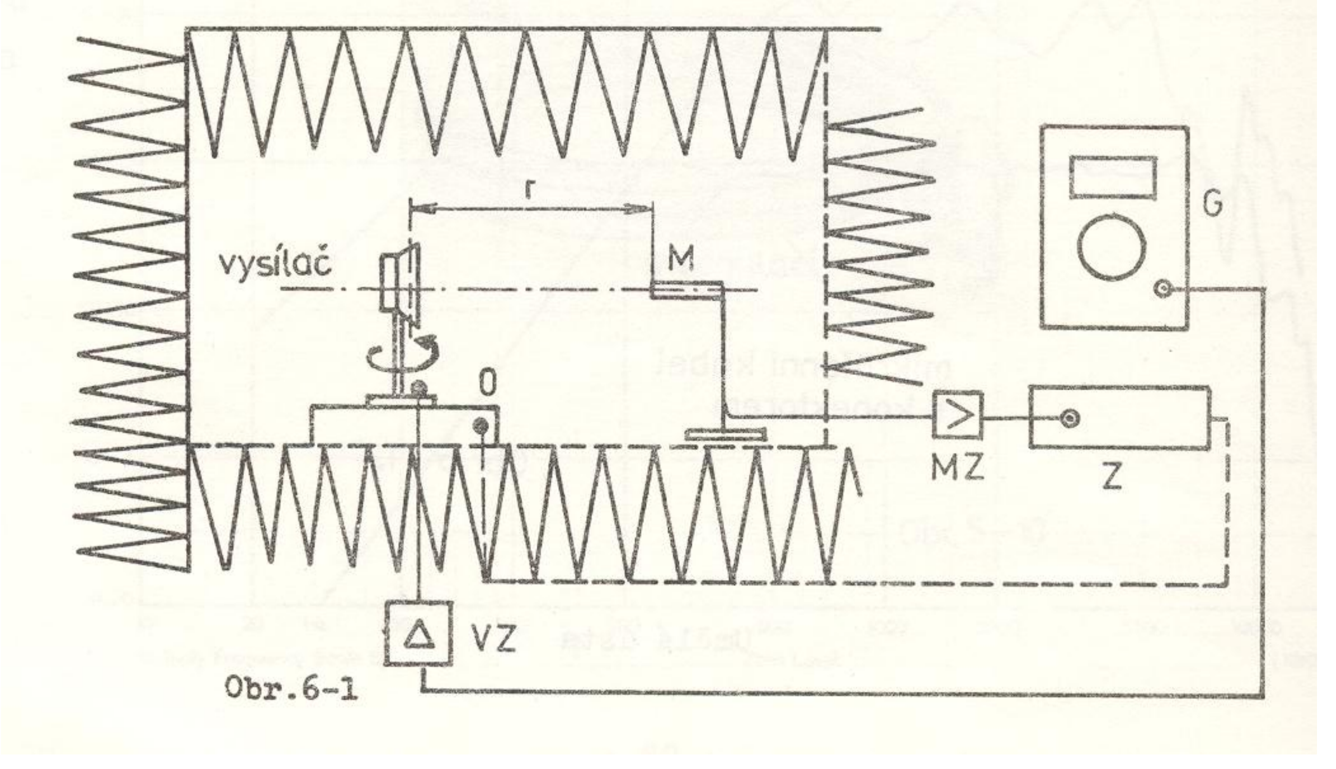
In spherical coordinates: $$dS = l^2 \sin(\vartheta) d\varphi d\vartheta, \varphi \in <0; 2\pi; \vartheta \in <0; \pi>$$

Total radiated power: $$P = \frac{l^2}{\rho c_0} 2\pi \int_0^{\pi} p_{\vartheta}^2 \sin(\vartheta) d\vartheta$$

Pressure of the omnidirectional source (0th order transmitter), having the same power as the measured transmitter

$$\mathbf{P = 4\pi l^2 \frac{p_s^2}{\rho c_0} \Rightarrow p_s^2 = \frac{P\rho c_0}{4\pi l^2}}$$

$$\int_0^{\pi} p_{\vartheta}^2 \sin\vartheta \, d\vartheta = 2p_S^2$$



Numerical characteristics of transmitter directivity

Directivity factor

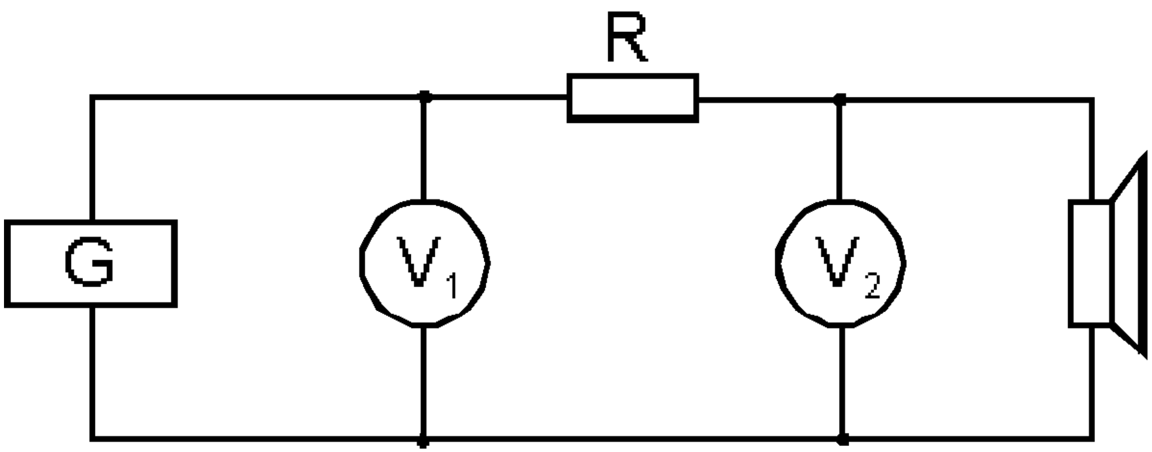
$$\sigma = \frac{p_\vartheta^2(\vartheta = 0, l = const.)}{p_S^2(l = const.)}$$

Directivity index

$$G = 10.\log\sigma$$

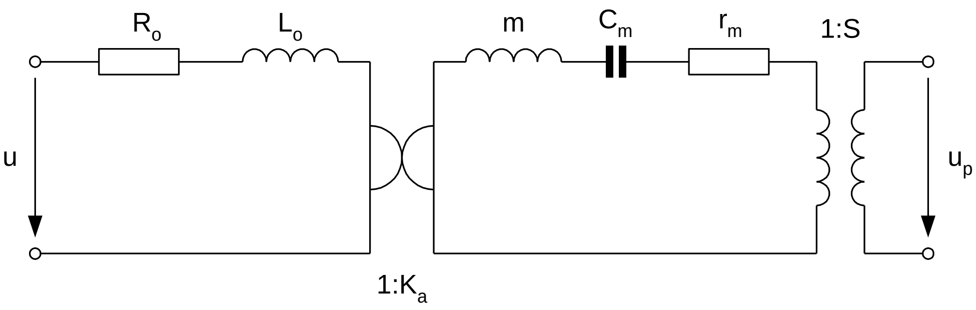
Measurement output: directional characteristics, total power, σ and G.

Measurement of input electric impedance of an electrodynamic loudspeaker in a closed and bass-reflex enclosures

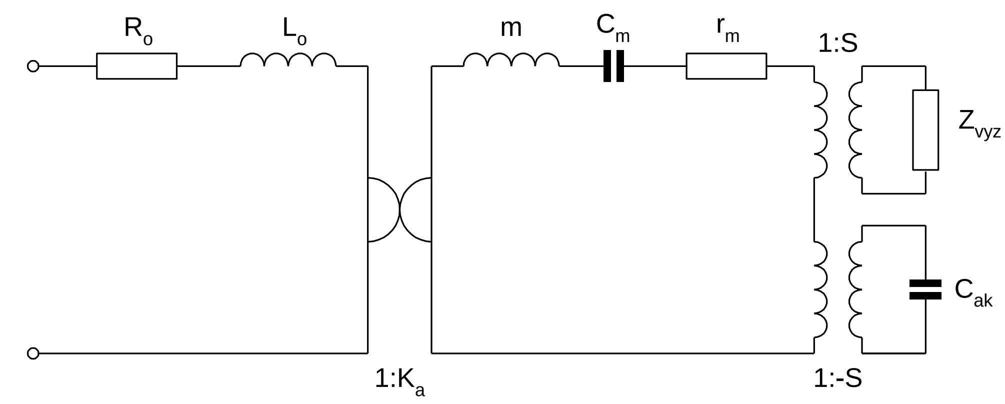


$$Z = \frac{U_2 R}{U_1 - U_2}$$

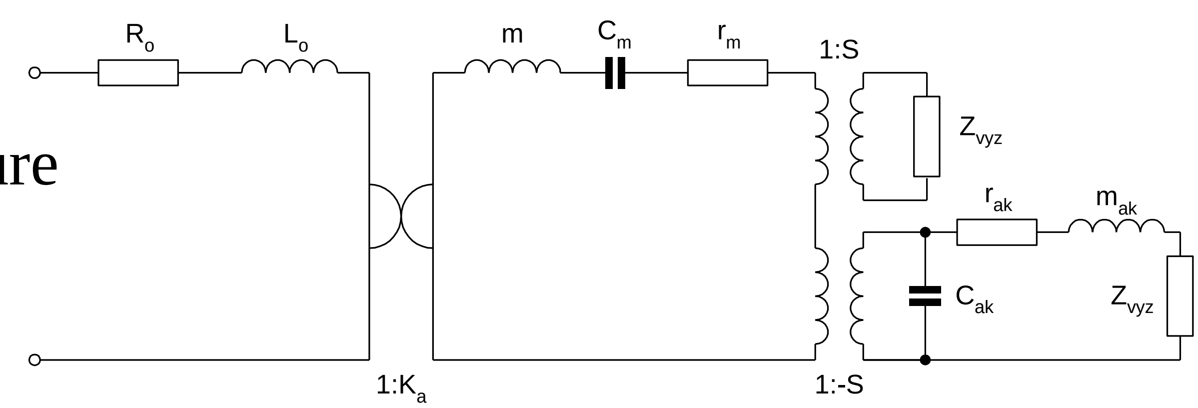
Without an enclosure



In a closed enclosure

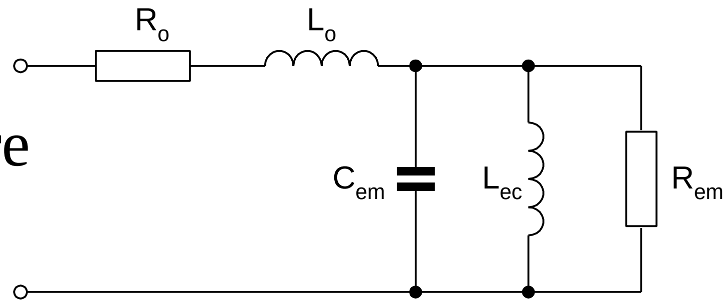


In a bass-reflex enclosure

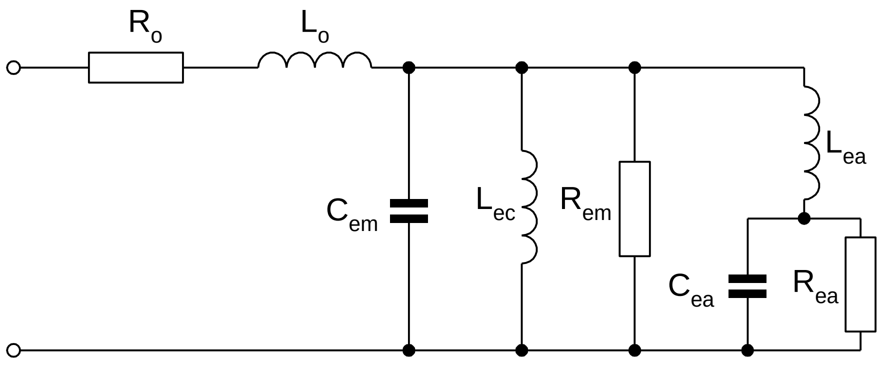


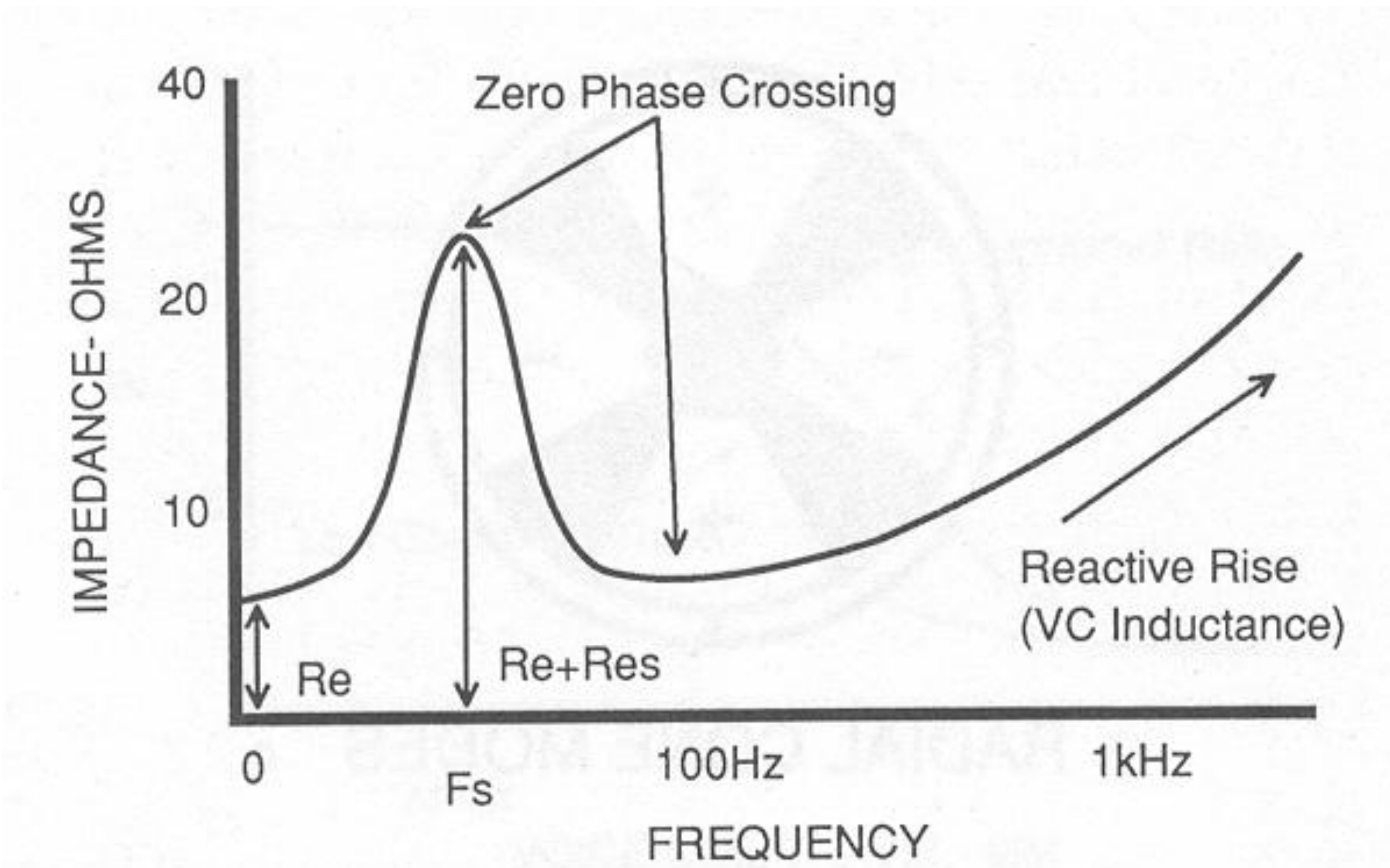
Transformation to electric sides

Loudspeaker without an enclosure
and in a closed enclosure



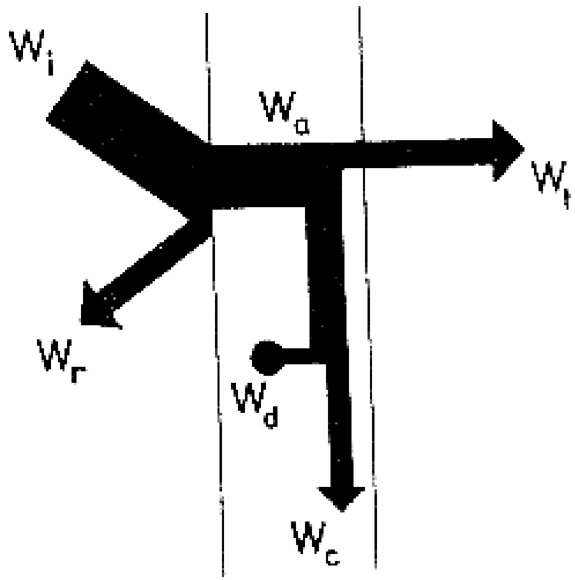
Loudspeaker
in the bassreflex enclosure





Output: Input electric impedances traced in one graph

Measurement of the sound absorbtion coefficient in the Kundt tube



$$\alpha = \frac{\mathbf{W_a}}{\mathbf{W_i}}$$

Characterizes basic acoustic quality of a surface of a wall

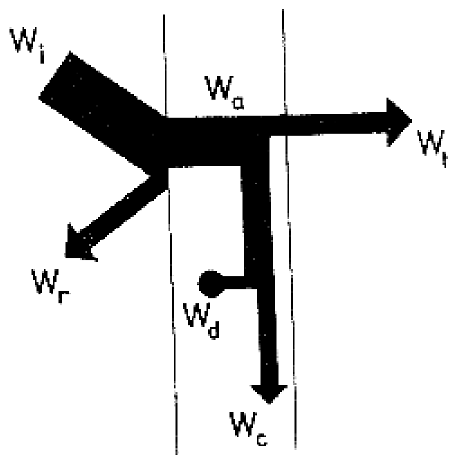
Absorption of a wall $A = \alpha . S$

Sabine's reverberation time $T = 0{,}164 \frac{V}{A}$

Measurement pronciple: termination of a waveguide (its acoustic parameters) affects spatial distribution of a standing wave and its character

$$W_i = W_r + W_a \qquad\qquad W_a = W_d + W_c + W_t$$

$$\alpha = \frac{W_a}{W_i} = 1 - \frac{W_r}{W_i} = 1 - |\beta|^2 \qquad\qquad \tau = \frac{W_t}{W_i}$$



β...reflexion coefficient
τ..transmission coefficient

Measurement of pressure with a probe at maxima and minima

$$\mu_0 = \frac{|p_{\min}|}{|p_{\max}|} = \frac{(1-|\beta|)}{(1+|\beta|)}$$

μ_0 … standing wave ratio

$$\alpha_0 = \frac{4}{2+\mu+\frac{1}{\mu}} = \frac{1}{\frac{1}{2}+\frac{1}{4}\left(\mu+\frac{1}{\mu}\right)}$$

Sound absorption coefficient for perpendicular incidence

Sound absorption coefficient is frequency dependent

Usually measured at following frequencies

64 Hz	125 Hz	250 Hz	500 Hz
1kHz	2kHz	4kHz	8kHz

Because of the method the measurement range is 350-750 Hz

Output: α versus frequency curves

Sound signals and their assesment

- Characteristics of human hearing
- Review of basics from Signals and Systems
  - Time and frequency domain
  - Digital signal (sampling & quantization)
- Lossy compression of audio signals

Adobe Audition is used

Basics

- Frequency spectrum – analysis of unknown (periodic) signal – frequencies and levels
- Influence of sampling and quantization on frequency spectrum
- Analysis of Dirac pulse, impulse response of LP and HP creation

Hearing characteristics

- Frequency range of your hearing (swept signal)
- Dynamic range of your hearing (1 kHz), bit depth

Lossy Audio Compression

- Comparizon of 3 codecs (mp3, ogg vorbis, wma) artifacts on low bit rates – audible artifacts, time and frequency domain analysis
- The lowest bit rate for superior quality (for the three codecs)

Outputs

- Table – unknown signal spectrum
- Impulse response of LP and HP
- Your hearing frequency range for 3 levels
- Your hearing dynamic range at 1 kHz
- Compression artifacts in time, frequency and audible domain for 3 codecs
- Minimal bitrate for 3 codecs