Aalto University
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Communication acoustics
Ch 4: Electroacoustics and responses of audio systems

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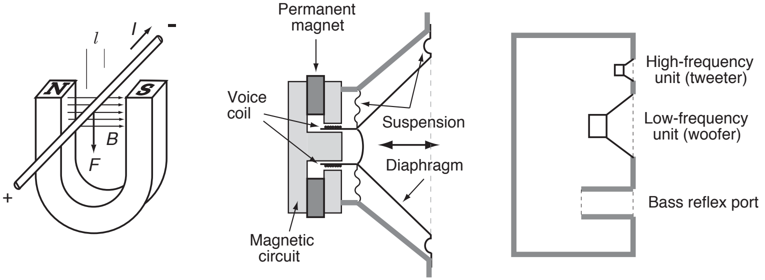
December 12, 2017

Dynamic loudspeaker



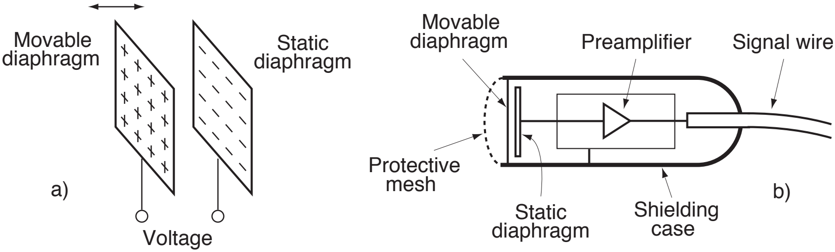
a) b) c)

- electric signal applied to coil
- current in coil applies force, which moves the coil and the diaphraghm
- mechanical movement of the diaphragm makes the air move

Headphones

- in the ear canal
- supported by the pinna (supraaural)
- cover the external ear entirely (circumaural)
- "closed headphones" try to seal the ears acoustically: leaks between the cushion and skin affect bass response
- "open headphones" have deliberate openings: more similar bass btw individuals
- issue with all headphones: since the driver is very close to the pinna or in ear canal, the transfer function depends on individual ear geometry. Acoustic conditions in ear change the response in arbitrary manner at high frequencies.

Condenser microphone



- sound pressure causes the diaphraghm to move
- voltage between diaphraghms changes weakly
- preamplifier transmits the signal further

Measuring the response of audio systems

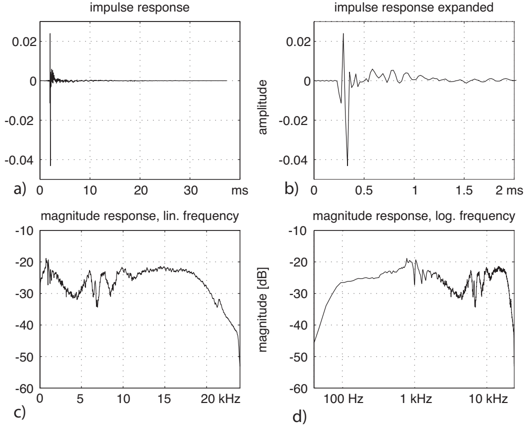
Apply a known test signal $x(t)$ to the system, and record output $y(t)$

$$y(t) = x_0(t) * h(t) + n(t)$$

Implement deconvolution in frequency domain

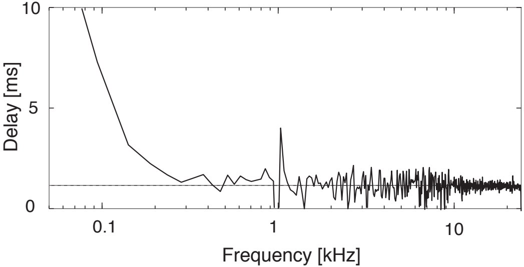
$$h(t) = \mathcal{F}^{-1} \frac{\mathcal{F}\{y(t)\}}{\mathcal{F}\{x_0(t)\}}.$$

Response of a loudspeaker



Group delay

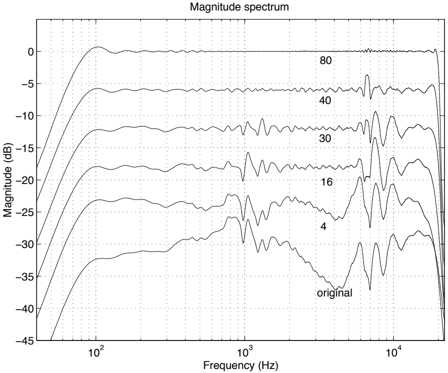
The group delay of a two-way bass-reflex loudspeaker on a logarithmic frequency scale.



Equalization of responses of systems

- the frequency range of hearing is broad, about 20Hz - 20kHz
- devices often fail to provide flat frequency response and constant group delay
- analog or digital filtering can be applied to "equalize" the output
- non-trivial task
- target response has to be measured in actual conditions where the device is used
- too aggressive equalization will cause other problems, such as increased non-linear distortion

Equalizing magnitude response in anechoic chamber



This equalization is valid only in anechoic listening for single listening position, in typical listening rooms the result is different in each listening position.

References

These slides follow corresponding chapter in: Pulkki, V. and Karjalainen, M. Communication Acoustics: An Introduction to Speech, Audio and Psychoacoustics. John Wiley & Sons, 2015, *where also a more complete list of references can be found*.